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Montana Renewable Energy Viability Project

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The design report was completed in September 1979 and published in April 1980.

Montana
Renewable Energy Viability
Project

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Energy Division
Montana Department of
Natural Resources and Conservation
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EXECUTIVE SUMMARY

INTRODUCTION

In the **Montana Renewable Energy Viability (REV) Project**, the potential of energy sources and energy conservation will be examined for use throughout the state of Montana.

Building on the substantial commitment of national, state and private research dollars toward renewable forms of energy, the project will:

Assemble pertinent technical information relevant to Montana

Assess the technical opportunities in terms of social, economic, and environmental effects

Identify and examine particular state and local actions which might influence the rate and type of sustainable energy development

The REV Project is designed to facilitate the implementation of existing state energy policies. The project builds upon existing research and planning experiences. It is designed to both draw upon and contribute to state energy programs in the areas of energy conservation, renewable energy sources and general energy planning.

The project will develop information regarding a possible energy future which is more reliant on energy conservation and renewable energy sources. Using a range of technical disciplines, the REV project will examine conditions at the state, local, and private levels. The project does not presuppose that some level of Montana's energy needs should come from renewable sources. Its task is to develop information in a framework which will permit conventional and renewable alternatives to be compared, using the same criteria.

The project will focus on the intermediate future, from the present to five to twenty years ahead.

SUPPLY/DEMAND ANALYSIS

Montana's energy future will be largely determined by individual consumers and producers making choices within the economic system. These supply and demand forces must be examined in order to identify the potential for conservation and new technologies. A model capable of explaining past behavior can project alternative energy futures as a function of relative costs, availability, and various government policy incentives.

THE SUPPLY/DEMAND ELEMENT: Description

The supply/demand model will provide the data collection and analysis necessary for comparing renewable energy sources and energy conservation with conventional alternatives. The basic data input on renewables and conservation will come from the technology, profiles and

resource assessment elements of the larger project. This information will be integrated with demand to forecast energy consumption by year, energy source, and end use. The model will be capable of identifying the effect of change in any of the major input parameters on energy consumption (such as the price of natural gas, the efficiency of appliances, or the installation cost of solar space heating systems). The effect of State and Federal energy policies (from the transition analysis project element) will also be examined. The yearly consumption from the supply/demand model is in turn the major input for the impact assessment element.

THE SUPPLY/DEMAND ELEMENT: Major Tasks

Task 1. Demand Model

The purpose of the demand model is to: provide a Montana specific forecast of future energy consumption by fuel and major consuming sector, and determine the sensitivity of the forecast to prices, income, population and other economic/demographic variables.

Task 2. Qualitative End-Use Data

A current and historical profile of energy use in Montana will be assembled. The profile will show sector of use, form and quantity of energy, and thermodynamic quality of energy use.

Task 3. Residential End-Use Simulation

End-use simulation will provide a method for determining the impact of changes in specific policies, (such as appliance efficiency standards or tax credits), technological improvements, (solar space heat) or price change on residential consumption. The price response identified in Task 1 will be disaggregated into effect of efficiency, appliance saturation, and use intensity.

Task 4. Other End-Use

This task identifies the potential for conservation and renewable energy alternatives in the commercial, industrial, transportation and agricultural sectors. Given the diversity of end uses and technologies in these sectors, much of the analysis will be industry or even firm specific.

Task 5. Supply Model

This task will specify in comparable terms (cost and availability) the alternative ways of meeting future energy demands. The future prices and availability of conventional fuels, conservation and renewables will include an adjustment for environmental costs of existing Federal subsidies.

RESOURCE ASSESSMENT

The purpose of this element is to generate working estimates of each major renewable energy resource available in Montana. This will include geographic, seasonal and annual variation. The element is to be accomplished by assembling the available information for each resource in a framework which will describe what is known and that interpolates between information points.

This element, together with the technology profiles, will be a major foundation of the economic supply/demand analysis.

THE RESOURCE ASSESSMENT ELEMENT: Major Tasks

Task 1. Solar Energy Assessment

This task will be accomplished by gathering existing solar radiation and cloud cover data. The data will be used to develop a model which will predict the time variation in solar radiation for various parts of Montana.

Task 2. Geothermal Energy Assessment

This task will be focused primarily on wet steam and hot liquid resources. The analysis will include performance estimates of geothermal sites under various usage scenarios.

Task 3. Wind Energy Assessment

This task will be accomplished by gathering existing wind speed and geomorphic data. The data will be used in a model to estimate the time variation in wind speed for various parts of Montana.

Task 4. Hydropower Assessment

This task will be carried out by reviewing the large volume of information on stream flows and hydropower potential in Montana.

Task 5. Wood Energy Assessment

Data necessary to assess the renewable energy potential of both live and dead timber resources will be assembled. Forested areas which might be managed for wood energy will be identified.

Task 6. Bio-mass Energy Assessment

This task will identify the amount of potential biomass sources and their individual unit energy potentials.

TECHNOLOGY PROFILES

A meaningful analysis of the viability of renewable energy technologies and conservation opportunities evaluates the various technologies to determine, the state of development, performance in Montana's harsh climate, costs, reliability, availability in the marketplace, the quality and quantity of energy produced or saved, and environmental/resource characteristics which determine suitability in particular site.

This element includes a written technical assessment and evaluation of the technologies under consideration, prepared in a consistent style and format and using internally consistent evaluation criteria. A matrix of technologies and evaluation criteria will be prepared as input to the supply/demand and impact elements.

IMPACT ANALYSIS

A project proposing to study the feasibility of increased use of energy supplied from renewable sources must concern itself with the economic and environmental impacts caused by such a shift in the energy supply mix.

Initially, the impetus behind the movement in our society for an expansion in the use of so-called "benign" energy technologies was due to the belief that these alternative energy supplies had less adverse environmental impacts than conventional, centralized systems. Lately, the need for effective policy making has expanded the criteria against which energy technologies must be judged. Pragmatic energy policy-making must carefully consider the regional and local economic impacts of the policy options under study.

IMPACT ANALYSIS: Description

The Impact Element is designed to examine and analyze the statewide and prototypical community economic, environmental and social impacts of a shift to renewable energy sources for supplying Montana's energy needs. This element will:

1. Incorporate environmental impact coefficients for the technologies under study developed in the Technology Profiles and the projections of energy supply mixes developed in the Supply/Demand element to develop a matrix of projected impacts from both conservation-induced reduction in impacts due to conventional sources and adverse impacts arising from the expanded use of renewable technologies. To the extent possible, impacts will be quantitatively described in terms of costs to humans.

2. Use the economic data for the technologies under study developed in the Technology element with the scenarios for rates of adoption and energy prices developed in the Supply/Demand element to project employment, income and population impacts associated with the various scenarios.

3. Pay particular attention to assessing local economic, environmental and social impacts in the prototypical study communities. These impact studies will be used as a coarse check on the aggregate impacts projected above.

4. The social impacts analysis will be based on the results of the surveys discussed in public input and participation as well as direct interviews and analysis.

PUBLIC INPUT AND PARTICIPATION

This element deals with some of the relationships between the REV project and the general public. The public will play roles as advisors on project decisions and as participants in project activities in the model energy communities.

Public input will help to ensure that the project is responsive to the needs of a broad spectrum of Montana residents.

Project researchers will encourage public participation by following this plan:

Task 1. Review Work Plan and Assign Implementation Responsibility

Task 2. Publicize the Project and the Opportunities for Public Input

Task 3. Conduct Interviews with Representative Individuals

Task 4. Design and Conduct a Statewide Public Opinion Survey

Task 5. Create a Statewide Citizen Advisory Committee

Task 6. Make Periodic Mailings to Interested Parties

Task 7. Identify State Government Liaison Personnel

Task 8. Community - Publicize the Project and the Opportunities for Public Input and Participation

Task 9. Community - Conduct Interviews with Selected Individuals

Task 10. Community - Conduct a Community Opinion Survey

Task 11. Community - Create a Local Citizen Advisory Committee

Task 12. Establish a Local Volunteer Program

INFORMATION DISSEMINATION

The objective of this element is to distribute information on the opportunities for, and desirability of renewable energy sources.

Primary identified audiences are: energy policy makers and implementers at the state level, local government officials, residential, commercial, and agricultural users of energy, intermediaries such as bankers and architects, and members of the general public may also use the information gathered by this project.

Project researchers will disseminate information by following this work plan:

Task 1. Review Work Plan and Assign Implementation Responsibility

Task 2. Conduct Interviews with Audience Representatives

Task 3. Include questions in the Public Opinion Surveys

Task 4. Publicize the project and its Research Findings

Task 5. State - Make Periodic Mailings to Interested Parties

Task 6. State - Publish and Distribute Technical Materials

Task 7. State - Make Computer Models Available to Others

Task 8. State - Produce and Distribute State Policy-Focussed Reports

Task 9. State - Consult with State Policy Makers and Implementers

Task 10. State - Establish an Information Referral Service

Task 11. Community - Produce and Distribute Local Policy-Focussed Reports

Task 12. Community - Produce and Distribute Non-Technical Leaflets

Task 13. Community - Conduct Informational Workshops

Task 14. Community - Provide Individual Consulting Services

Task 15. Community - Help Establish an Energy Library and Reference Service

TRANSITION ANALYSIS

The viability of renewable energy sources and energy conservation is not strictly a technical question. Changes contemplated by individuals or by society must meet many tests before gaining acceptance. The transition analysis element looks at the state level and at sub-state geo-political areas to determine the viability of the renewable/conservation option. The findings from the analysis of "model energy communities" will be synthesized for application to other communities. State level implications will be identified and analyzed.

THE TRANSITION ANALYSIS:
Description

This element focuses on "model energy communities" competitively selected from the cities, towns, counties and Indian reservations of Montana. The project examines all facets of energy use in the four communities. Beginning with local energy and economic profiles, the project applies technical analysis in the areas of energy resource assessment, technology profiles and energy supply and demand to assemble possible combinations of conservation measures and renewable energy technologies. Scenarios of possible energy futures will be based on a continuation of historical experience as well as a major commitment to conservation and renewable sources.

The microeconomic supply/demand analysis at the local level will use forecast costs of conventional energy supplies, and will perform comparative economic studies of conservation measures and renewable technologies, considering both private and social costs.

In the local level transition analyses, specific technical strategies will be examined on the basis of social and political aspects. Environmental, economic and social impacts will be evaluated. Members of the public will participate from the beginning and all findings will be publicly available.

The level of detail at the local level will allow residents of the community to pursue actual developments. Such decisions are community choices and could be based on goals for economic development, least-cost energy, or social concerns.

At the state level, the barriers and incentives analysis from the component will be examined. Pertinent findings will be synthesized for general information and assessed for state policy implications.

The local component is dependent upon the provision of technical assistance from the state effort and much of the state effort is built upon local findings.

THE TRANSITION ANALYSIS: Major Tasks

The Transition Analysis element contains two major task areas: local transition analysis (LTA) and state transition analysis (STA).

Task LTA 1. Select Model Energy Communities

Four communities will be competitively selected. They will serve as data gathering points and will receive concentrated technical assistance from the project energy analysis team.

Task LTA 2. Community Organization

This task encompasses the broad function of dealing directly with the community, including hiring and training local coordinators, forming a local advisory committee, working with special local sub-groups, and regular reporting to the local governing body.

Task LTA 3. Community Analysis

Under the broad heading of community analysis: energy and economic data are assembled; resource, technology and impact information is provided by the state REV team; and this information supports an analytical process in which the supply/demand analysis results in the formulation of local energy scenarios for conservation and renewable energy. The technical information is subjected to a barriers and incentives analysis, identifying necessary and sufficient educational, market, and regulatory conditions to obtain scenario levels. The social, economic and environmental impact evaluation completes the community analysis.

Task LTA 4. Community Information

This task is included in the public information element.

Task LTA 5. Implementation Support

If warranted by the facts and circumstances, this task will provide initial technical support to pursue implementation.

Task LTA 6. Synthesis

This task will result in written synthesis of the findings for application elsewhere.

Task STA 1. State governmental REV sounding board.

This board will be established to observe project performance and to discuss possible policy/program recommendations.

Task STA 2. Barriers and incentives analysis.

This analysis will identify and discuss the necessary and sufficient conditions to reach scenario levels or to emplace candidate technologies.

Task STA 3. Facilitating strategies.

This task will develop possible strategies for removing barriers or providing incentives.

Task STA 4. Impact mitigation strategies.

This task will identify negative impacts of facilitating strategies and discuss how they can be mitigated.

INTRODUCTION

In order to facilitate public and private choices for the appropriate mix of energy solutions, it is essential to look at all potential energy alternatives in a rigorous and consistent manner. Recent economic history has provided information about the costs, benefits, and impacts of using conventional forms of energy. But as Montana and the nation move into a period of uncertain fossil fuel supplies, rising real prices, changing relative prices, and uncertain health and environmental risks, competent information about energy alternatives becomes important to government and private decision-makers alike. What are the renewable technologies? How well do they perform in a harsh northern climate? What do they cost? What else do they require, (space, southern exposure, wood,...)? How do they compare with traditional energy supplies? What are the local social, economic, and environmental effects?

The principal party in REV, the Montana Department of Natural Resources and Conservation has a responsibility to examine various aspects of conventional energy supply options. Under the Montana Major Facility Siting Act this includes coal-fired power plants, synthetic fuels from coal, nuclear reactors, and hydroelectric dams. DNRC has review responsibility for a proposed major crude oil pipeline and a proposed major natural gas pipeline. The Department also operates the State Energy Conservation Program and manages the Alternative Renewable Energy R & D Program, which is funded by coal severance tax revenues.

MONTANA'S ENERGY POLICY

The energy policy of the State of Montana has been formed by law, executive order, public policy statements, and administrative directives. Montana has expressed and demonstrated a meaningful commitment to energy conservation and renewable energy sources.

The Montana Department of Natural Resources and Conservation (DNRC), Montana's principal energy agency, has recently published a comprehensive reference source concerning Montana's energy legislation, policies, and programs. The **1978 Montana Energy Almanac** (Kuntz, 1979) represents an up to date profile of Montana's energy policies and programs. A paragraph from its introduction places renewables and conservation in the policy picture.

In his energy message to the 1977 Legislature, Governor Judge stated that Montana has been the nation's leader in design and enforcement of environmental safeguards, but that in the future, "Montana should become the nation's leader in conservation of its energy resources and elimination of waste in their usage. ...The number one priority and the basic cornerstone of our energy policy must be reduction of energy demand; any other course is ultimately suidical." The Governor has also stated the administration's belief that "the only permanent solution to the energy problem lies in the development of renewable, alternative energy sources." Conservation and renewable energy sources are central features of a number of the state energy programs described in this report. (Kuntz, 1979)

THE REV DESIGN REPORT

To produce the REV design report, a prime consultant teamed with private and academic specialists to perform the background technical research and technical writing. The design team was assisted by a broad-based citizen's advisory group formed for that purpose. DNRC policy and technical staff members were involved in the project from its outset. The experience of the design project is an example of the close cooperation and effective working relationships developed in Montana among various units and levels of government, the private research community, and the academic sector. Resumes of the members of the design team have been included in the appendix to demonstrate the qualifications of those who participated in the technical preparation of the report.

MANAGEMENT PLAN

The responsible principal in the project is the Montana Department of Natural Resources and Conservation (DNRC) a statutory cabinet-level executive agency. As the principal energy agency of the State of Montana, the Department and its energy program responsibility will be functioning long after this project is completed. Much of the work upon which the project is based has been completed under the auspices of the Department, and it is clear that the primary responsibility at the state level for follow-through and implementation resides here.

The primary related energy programs of DNRC are:

Major facility siting

Alternative renewable energy

Energy Conservation

These and other DNRC and State of Montana energy programs are discussed in the 1978 **Montana Energy Almanac** (Kuntz, 1979).

MANAGEMENT STRUCTURE

The REV Project Management structure, essentially similar to other projects run by the Department, is a hybrid of professional staff, contracted services, and in-kind matching/volunteer services (from the local level). Figure 1 portrays the broad project organizational structure.

Administrative and fiscal control are necessary for responsible and effective performance. The Department has a proven record of administering funds and managing large multi-disciplinary projects. The Department routinely administers federal funds from various sources and is regularly audited by the State of Montana.

The management strategy of hiring a professional program manager, using selected in-house professionals and contracting for additional services, has worked effectively in major Departmental projects. The program manager is responsible for the day to day management, direction, and coordination of the project.

Table 1 specifies major program elements and tasks and identifies their suitability for in-house (DNRC), interagency (identified), University, or private sector (consultant) performance. Montana governmental procurement policies permit both sole source and competitive selection. The design project was administered in a similar fashion using in-house, university, and private sector resources.

No commitment, express or implied, has been made by DNRC to any potential participants, although the Department is confident that a fully competent team will be assembled when funding becomes available.

THE TASK APPROACH

For better management and understanding, the project has been partitioned into separate tasks. The tasks are the major building blocks of the project. Tasks can be broken into sub-tasks and activities. Obviously, there are important relationships among many tasks. It is often necessary for tasks to be performed in a particular chronological order. Besides giving a clearer picture of the actual building blocks of the project, the task format allows explicit assignments and contractual arrangements.

Table 2, REV project timetable, depicts the entire project expressed as elements and tasks. The two year project period is broken into months 1 through 24.

Specific substantive questions regarding a particular element should be referred to the section of this design report covering that element.

Figure 1. Project Organizational Structure

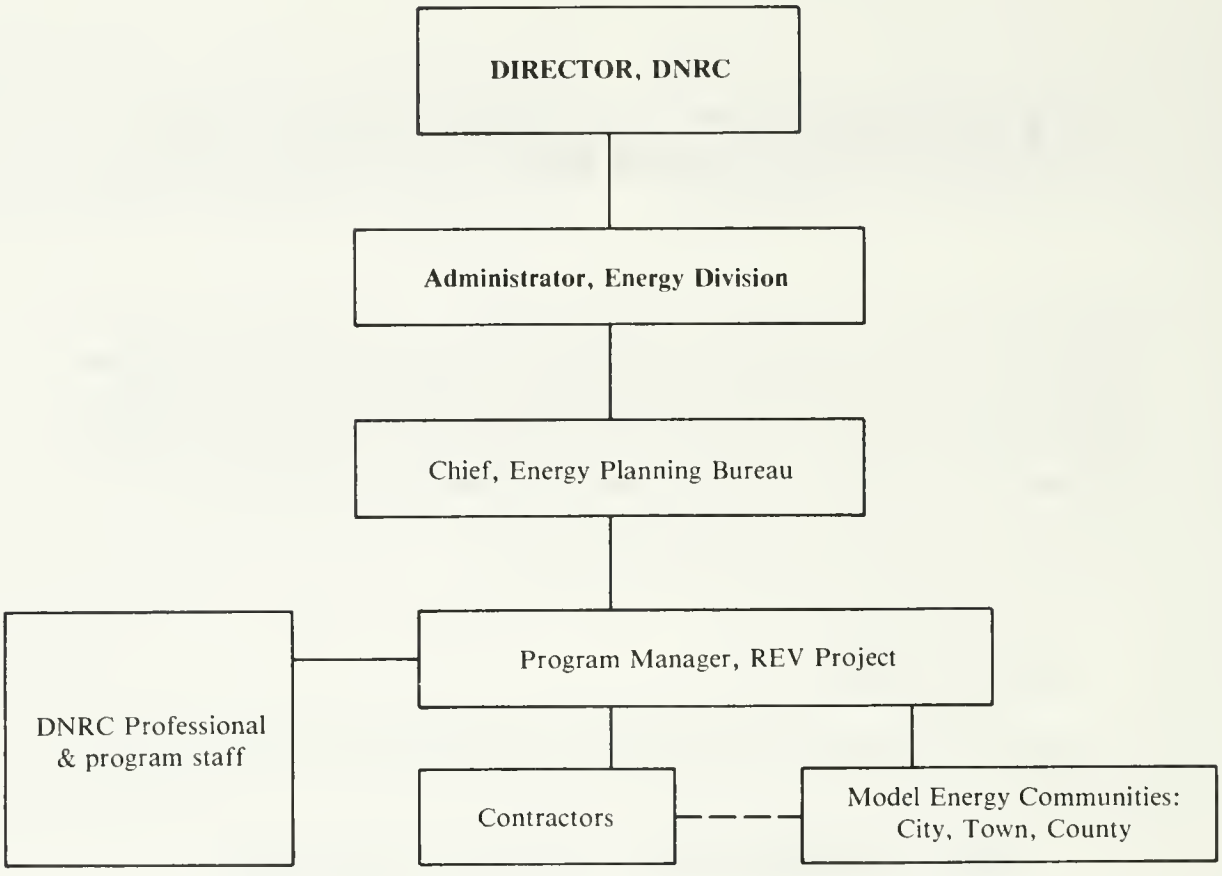


Table 1. Major Program Elements: Suitability for Performance

Program Element	In-House (DNRC)	Interagency (Identify)	University	Private
Management and Administration	X			
Supply/Demand	X		X	X
Technology Profiles			X	X
Resource Assessment		Water Resources Div., DNRC	X	X
Transition Analysis	X		X	X
Impact Analysis				
Economic		Mt. Dept. of Comm. Affairs	X	X
Environmental	X		X	X
Social			X	X
Public Input and Participation	X		X	X
Information Dissemination	X		X	X

Table 2. Montana Renewable Energy Viability Project Major Activity Timetable

PROJECT COMPONENT	MONTH 1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24
Management and Administration[1]	■	■	■	■	■
Supply/Demand	■	■	■	■	
Technology Profiles	■	■	■	■	
Resource Assessment	■	■	■	■	
Transition Analysis					
Local		■	■	■	■
State		■	■	■	■
Impacts					
Economic		■	■	■	
Social		■	■	■	
Environmental		■	■	■	
Public Input and Participation	■	■	■	■	
Information Dissemination		■	■	■	■

[1] Extends 6 months before full start-up and 6 months after month 24

COORDINATION

The REV project involves both state and local governmental levels as well as contracted professional services, a situation which creates special demands for coordination.

Project success is dependent upon having a program manager who fully understands the project and who can communicate effectively with members of the project team and foster exchange among team members.

As communication and performance assurance measures, the following are included:

Quarterly team meetings — held in the following months:

1. Helena
3. Helena
6. Helena or at a campus
9. Model Community
12. Helena
15. Model Community
18. Model Community
21. Model Community
24. Helena

Quarterly written interim progress reports by responsible project team members.

An interagency renewable energy policy group will be formed and will meet in months 2, 7, 13, 19 and 24. A broad solar advisory group has been set up and will be kept apprised of REV progress. The project will also set up cooperation with the Renewable Energy Advisory Council and the Gasohol and Biofuels Advisory Council.

MANAGEMENT OF THE MODEL ENERGY COMMUNITY PROJECTS

Management of those project components involving the model energy communities poses some unique requirements.

Once the communities are selected (see Transition Analysis, Task LTA-1), it will be necessary to enter into a Memorandum of Understanding (MOU) between DNRC and the governing body of the local community. The MOU, which must be formally authorized by vote of the governing body, is a commitment of local support to the project (office, limited clerical, access to elected officials and staff, organizational support for public involvement). DNRC's commitment will be to provide technical and administrative suport to the community analysis.

The key project figure in the community component is the (community) project coordinator. This is a full-time person employed in the community from months 7 through 24. The project coordinators are responsible to DNRC via a contractual relationship. They report to the project manager for direction and supervision. They must be able to work independently, and they must work closely with the community. The organizational structure is depicted in Figure 2.

In following sections of the design report, the major project elements are discussed in detail.

Figure 2. Organizational Structure - Model Energy Communities

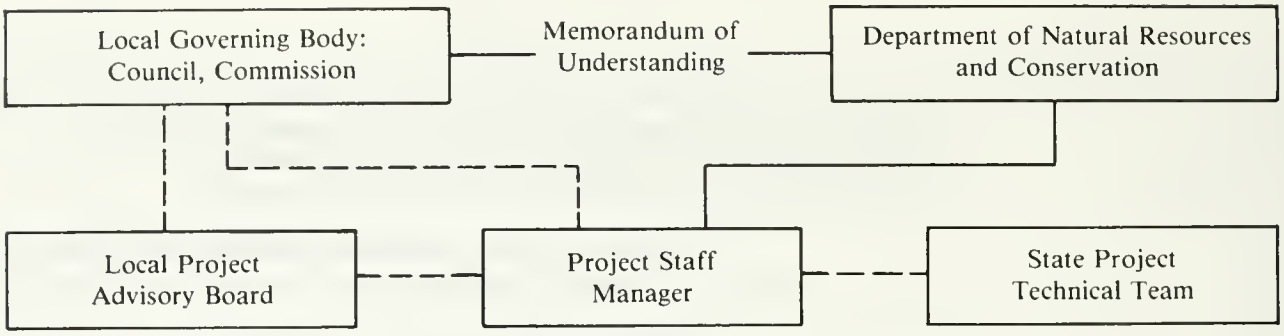

Local Governing Body: Council, Commission
Memorandum of Understanding
Department of Natural Resources and Conservation
Local Project Advisory Board
Project Staff Manager
State Project Technical Team

Table 3. Budget: Management and Administration

	Year 1		Year 2		Total
Personnel					
Professional	1.5 FTE @ $20,000*	$30,000	1.5 FTE @ $21,400*	$32,100	$ 62,100
Editor			.5 FTE @ $16,050	8,025	8,025
Subtotal		**30,000**		**40,125**	**70,125**
Benefits (17%)		5,100		6,821	11,921
Personnel Costs		35,100		46,946	82,046
Travel		1,500		1,500	3,000
Computer		—		—	—
Printing		1,000		4,000	5,000
Other		—		—	—
Subtotal		37,600		52,446	90,046
Overhead (15%)		5,640		7,867	13,507
TOTAL COST		**$43,240**		**$60,313**	**$103,553**

* Accounts for project manager on duty six months prior to year one and six months after year two for preparation and wrap-up.

SUPPLY/DEMAND ANALYSIS

SUMMARY

This element of the REV project describes the data collection and analysis necessary for comparing renewable energy sources and energy conservation with conventional alternatives. Figure 3 provides an overview of how the supply/demand analysis relates to the other major project elements. Given exogenously determined economic, demographic, technical and policy parameters, the supply/demand simulation model will forecast energy consumption by year, energy source, and end-use. The model will identify the effect of a change in any exogenous parameter (such as the price of natural gas, or the efficiency of refrigerators, or the capital cost of solar space heating systems) on energy consumption. Several specific scenarios that will be investigated are:

1. conventional/baseline - no new technologies but continued efficiency improvements in existing technology; no policy incentives for conservation or renewables.

2. least cost - the energy consumption path described by the least cost combination of conventional fuels, renewables, and conservation (i.e., assumption of perfectly rational and informed consumers and producers).

3. renewables, no incentives - same as 2 but with market penetration by renewables and conservation alternatives.

4. renewables, rational policy - same as 3 but including all cost-effective policy incentives to overcome market failure.

5. maximum renewables - examines the technical feasibility of an entirely renewable energy based Montana economy. (Corresponds roughly to the "outcomes" scenarios in U.S. Dept. of Energy **Distributed Energy Systems in California's Future**).

Comparison of the major scenarios will provide the following information:

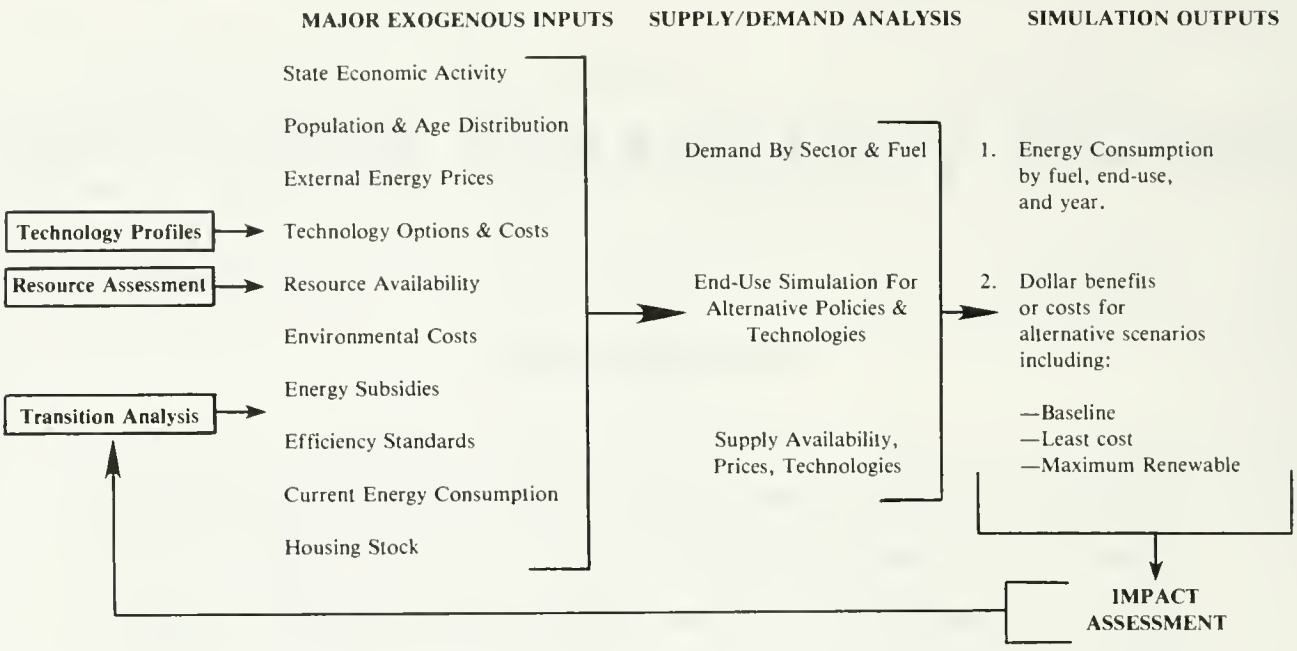
1. the costs or benefits in dollars and energy equivalents (BTU's or joules) of reliance on conventional fuels alone vs using renewables (1 vs 4).

2. the benefits of state and federal energy policy incentives (3 vs 4).

3. the costs of market failure (crude upper limit for rational policy investments) (2 vs 3).

4. the feasibility and costs of an economy entirely based on renewables (5 vs 4, 3, 1).

Figure 3. Relationship of Supply/Demand Analysis to Other Project Elements



The model is capable of examining the implications of goals besides least cost (or equivalently, maximum efficiency). For example, Scenario 5 may be of interest with regard to ethical (minimize environmental impacts), distributive (maximize Montana employment) or rational goals (energy self-sufficiency, balance of payments or defense concerns). This multi-objective analysis will be similar in spirit to work that has been done at the Brookhaven National Laboratory on highly aggregated alternative national scenarios (Cherniavsky *et al.*, 1977).

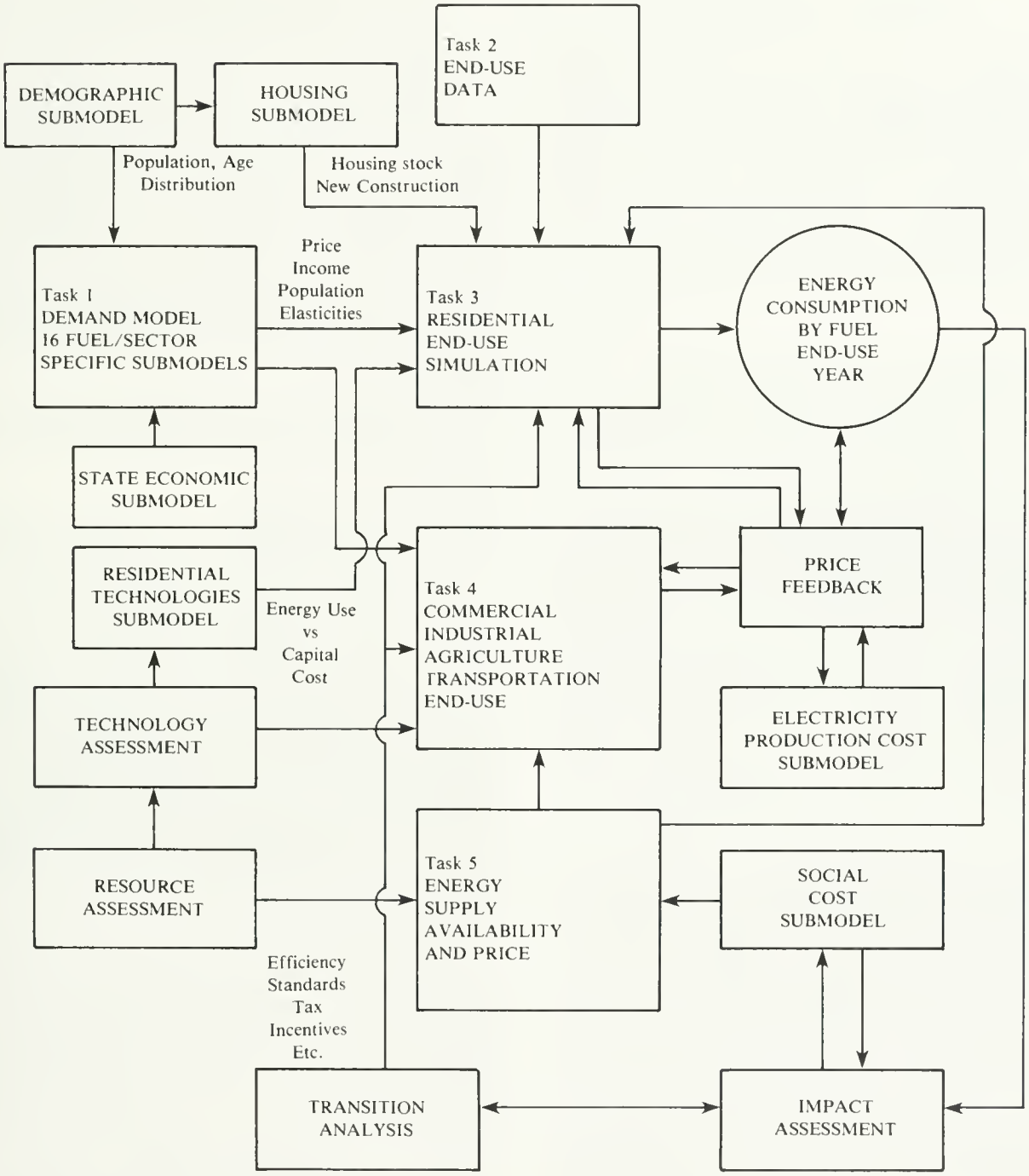
Of equal importance to the highly aggregative policy analysis implicit in the major scenarios is the potential for analysis of the impacts, benefits/costs, and feasibility of specific policy issues such as:

- appliance efficiency standards
- building insulation standards
- taxes on fossil fuels (gasoline, coal)
- subsidies for renewables, conservation or conventional energy sources
- mandatory fuel switching by industrial or utility users
- changes in environmental standards (or effluent taxes)

The relations of the major tasks involved in the development of the supply/demand model are illustrated in more detail in Figure 4. Task 1 is the construction of a highly aggregated econometric demand model for Montana by fuel and major end-use. Task 2 is the collection of qualitative end-use data for Montana and specific communities. Based on price, income, and population elasticities from Task 1 and current end-use data from Task 2, detailed end-use simulation models will be constructed (Tasks 3 and 4). Given energy prices, capital costs, resource availability, and technologies from Task 5 (supply), the end-use simulation model will predict energy consumption by fuel, end-use and year. For the residential sector, the output will be quite detailed (six housing types, four fuels, and eight end-uses).

In the remainder of this section, each of the tasks outlined in Figure 3 are discussed in greater detail.

Figure 4. Schematic of Major Supply/Demand Analysis Components



TASK 1. DEMAND MODEL

RESEARCH OBJECTIVES

The purpose of the demand model is threefold: (1) to provide a Montana specific forecast of future energy consumption by fuel and major consuming sector; (2) to determine the sensitivity of the forecast to energy prices, personal income, population, and other economic/demographic variables; (3) to develop aggregated but accurate cross-price and price elasticities for input to the detailed end-use simulation (Tasks 2 and 3).

PRESENT STATUS OF RESEARCH

There is a great variety of forecasting methodologies (Cohen, 1975; Ernst and Ernst, 1976; SRI, 1975), ranging from simple trending to complex engineering/econometric models. Given research objectives (2) and (3) (above), some type of econometric specification is necessary. The very large number of econometric energy models described in the literature differ largely in terms of *comprehensiveness* (number of fuels or sectors covered, e.g.: residential electric vs. all fuels, all sectors), *disaggregation* (specificity by end-use, e.g.: total industrial energy *vs.* industrial by SIC, e.g.) and *internal consistency* or completeness. Internal consistency varies from simple demand models that take price as an exogenous variable to models that derive prices endogenously through supply-demand iteration.

The choice of a forecasting model is a trade-off of increased accuracy and information (more comprehensive, disaggregated, and internally consistent) versus increased costs, data requirements and complexity. A recent literature survey (Otis and Duffield, 1979) concluded that the forecasting needs of the State of Montana could best be met by construction of a model largely similar to that now being used by the Oregon Department of Energy (ODOE, 1977a, b and 1978 a, b, c - described below in subtask 1). Thirteen other state and regional models were examined in the survey (MERDI, 1976; Boyd, 1976; NEPP, 1977; Polzin, 1978a; Hinman *et al.*, 1975; PNUCC 1978 and 1978b; Anderson, 1976; A.D. Little, 1976; SRI, 1977; Foell *et al.*, 1975; Chern *et al.*, 1976; and MEAC, 1976).

This model, presuming it is developed by the state, could also fulfill the major objectives of Task 1 of this project.

SUBTASK DESCRIPTION

Subtask 1. Fuel/Sector Specific Submodels

The Oregon model is basically a set of demand submodels with price taken exogenously. The general specification is a geometric lag with constant elasticities. This approach is a common one in the literature (Cohn, 1977; Houthaker, 1974; Mount, 1973, and Taylor, 1975), and is compatible with the needs of the end-use simulation (Tasks 3 and 4) discussed below. The Oregon model is composed of sixteen major submodels, some of which are energy specific (residential electric) while others are "total energy" models with fuel split equations (commercial) (see Table 4).

Presuming that the state adopts this demand model, the REV project would require staffing to serve as a liaison for use in simulation runs.

Subtask 2. Demographic

(See Subtask 3 below)

Subtask 3. State Economic

These subtasks would entail developing estimates of future population (and age distribution) and estimates of state economic activity by sector as inputs into the demand forecasting and housing models (Table 4). For the demographic subtask, state-specific forecasts by the U.S. Water Resources Council (the OBERS Projection) and the Bureau of the Census (**Current Population Reports**) would be compared and modified in light of population forecasting being done by the state at the Department of Community Affairs.

Forecasts of state economic activity would also be surveyed, rather than attempting to construct a Montana economic model. The major alternatives at the national level are: (1) Private state-specific forecasts by Chase Econometrics and National Planning Associates or (2) the OBERS projections. The latter are probably preferred, given the cost, short track record, and unstated methodology of the private forecasts. In any case, more specific work on Montana economic forecasting being done at the University of Montana Bureau of Business and Economic Research should be examined for improvement and modification of the basic OBERS projections (for example, Polzin, 1976, 1977, 1978b and Johnson, 1976, 1977, 1978).

Table 4. ODOE Submodels[1]

Energy Type	Residential	Commercial	Industrial	Agricultural	Transportation	Other
Electricity	*	*	*	*	*	*
Natural Gas	*	*	*			
Petroleum						
Distillates	*	*			*	*
Residual Oil			*		*	*
Gasoline			*		*	
Propane	*					*
Jet Fuel					*	

[1] Asterisks enclosed in a box refers to a combined treatment of that sector's demand for those energy types within one submodel.
SOURCE: Otis and Duffield, 1979

TASK 2. QUALITATIVE END-USE DATA

Recent analyses of various renewable energy technologies and of conservation options have emphasized the importance of beginning the analysis at the point of end-use. Man uses energy for various purposes, for example, heating and cooling buildings, mechanical work, lighting, transportation and refining metals.

Although energy analysts commonly express all forms of energy in standardized units, such as quads (quadrillion BTU's), or barrel-equivalents of oil, the various forms of energy are not freely interchangable. By breaking energy use into end-use categories, it is possible to match the thermodynamic characteristics of various forms of energy with the requirements of specific applications. Although this does not remove the need for microeconomic comparisons, or for looking at the impacts of technologies, it permits two important matters to be scrutinized. First, it provides an understanding of the physical possibility of satisfying energy demands with various alternative sources. Secondly, it provides a foundation for analyzing the potential for improving the second law efficiency of energy use through cascading (putting lower grade "waste" heat to a beneficial use) and thermodynamic matching of source to use.

For example, certain energy applications, such as thermal electric power generation, require a high temperature gradient in order to perform their function. However, they cannot use or convert all of the energy demanded by their process, resulting in the disposal of large quantities of lower grade heat. The typical modern coal-fired thermal power plant converts only slightly more than one-third of the coal energy into electricity. The balance is released into the environment as waste heat, usually via cooling towers.

By analyzing end-use, it is possible to identify opportunities for substantial improvements in energy efficiency. The end-use needs of the economy can be matched with the thermodynamic characteristics of the energy source.

The methodology for this task is quite straightforward. The project will draw on known sources of information, including:

- Appliance saturation surveys from the Montana Power Company (Wheeling, 1976)
- Census information from various censuses of housing; and manufacturers (Wheeling, 1976)
- The data base developed by the Energy Division, Department of Natural Resources and Conservation, through the conservation program, the general energy planning function and fuel allocation (Itami, 1979)
- The data-gathering of the OWRC-funded pilot project of the short term supply/demand forecasting system (Cook, 1979)
- Regular filing with FERC by the Montana-Dakota Utilities Company and other interstate utilities.

Through the model energy communities, the project will have access to selected community-specific sources of information, such as surveys gathering primary data on reliance on wood heat, for example. This will help to verify findings.

Various national and international studies, including work by Lovins (1977), the Oak Ridge National Laboratory (Liepins *et al.*, 1978), SRI (Clark, 1972), Energy Research Group (Knecht *et al.*, 1975; Bullard *et al.*, 1976) and others will be utilized to estimate relationships where data prove inadequate. The small number of in-

dustrial firms in Montana and their large energy use suggest that in that sector it will be necessary to use primary information, both from existing studies and through direct contact under the auspices of the REV project.

The analysis will begin with a breakdown of energy consumption by fuel, into the major sectors: residential, commercial, industrial, transportation and agriculture. Within each of these sectors are several sub-categories of energy use. Table 5 depicts total energy consumption in the five sectors, broken into end-use categories.

While such a depiction is extremely useful as a profile of energy use, it is still not sufficient to satisfy the needs of a thermodynamic end-use profile. Table 6, from Lovins (1977), depicts the kind of information which the project will develop based upon the data base from Table 5.

Because there is on-going research in this area, one of the first charges of the supply/demand team will be to review the strategy for developing the qualitative end-use profile, so that it is consistent with both accepted definitions adopted by other research projects and so that it is compatible with the supply/demand analytical model.

Table 5. Total Energy Consumption End-Use Sectors and Categories

TOTAL ENERGY CONSUMPTION

RESIDENTIAL (R)	COMMERCIAL (C)	INDUSTRIAL (I)	TRANSPORTATION (T)	AGRICULTURAL (A)
R_1 Space Heating	C_1 Space Heating	I_1 Space Heating	T_1 Auto/Truck (Gasoline)	A_1 Space Heating
R_2 Space Cooling	C_2 Space Cooling	I_2 Space Cooling, Ventilation, Refrigeration	T_2 Buses	A_2 Space Cooling
R_3 Water Heating	C_3 Water Heating	I_3 Water Heating	T_3 Truck (Diesel)	A_3 Water Heating
R_4 Lighting	C_4 Lighting	I_4 Lighting	T_4 Railroad (Freight)	A_4 Lighting
R_5 Appliances	C_5 Refrigeration	I_5 Process Heat	T_5 Railroad (Passenger)	A_5 Refrigeration and Appliances
R_6 Food Storage and Preparation	C_6 Food Preparation	I_6 Process Electricity	T_6 Aircraft	A_6 Process Heat
			T_7 Road Oil	A_7 Water Pumping
				A_8 Farm Vehicles (Gasoline)
				A_9 Farm Vehicles (Diesel)

TASK 3. RESIDENTIAL END-USE SIMULATION

RESEARCH OBJECTIVE

The purpose of residential end-use simulation is to provide a method for determining the impact of changes in specific policies (such as appliance efficiency standards), technological improvements or innovations (solar space heat) or price changes on residential energy consumption.

PRESENT STATUS OF RESEARCH

Many state and regional forecasting projects attempt to integrate detailed end-use into the residential sector. The dominant approach is to use some variant of an econometric-engineering appliance saturation model. The major issue is how price sensitivity should be incorporated. For example, the Northwest Energy Policy Project (NEPP, 1977) and Anderson (1976) basically provide an econometric analysis of saturations only. A most comprehensive model has been developed at the Oak Ridge National Laboratory (Hirst and Carney, 1978), a variant of which is being incorporated by Oregon in the ODOE forecasting model. The Oak Ridge approach is preferred for its detailed price sensitivity information. In addition, this model is well-developed and has already been applied to a number of issues, such as a regional analysis of the dollar and energy benefits of residential hot water heating options (solar with and without incentives vs. electric heat pumps) (O'Neal *et al.*, 1978a).

The Oak Ridge model is also compatible with the more aggregated output of the Task 1 demand model.

Table 6. 1973 U.S. Deliveries of Enthalpy by End Use (10^{15} BTU/y) (Enthalpy is a measure of heat content)

Sector	Heating and Cooling $\Delta T < 100°C$	Heating and Cooling $\Delta T \geq 100°C$	Portable Liquids	Misc. Mech. Work	Obligatorily Electrical[1]	Lost at Power Stations
Residential total	**8.72**	**0.62**			**0.52**	**4.21**
space heat	6.48					0.71
water heat	1.54					0.59
air conditioning	0.32					0.68
refrigeration	0.38					0.80
cooking		0.46				0.17
lighting					0.26	0.56
clothes drying		0.16			0.01[2]	0.17
other electrical					0.25	0.53
Commercial total	**5.93**	**0.15**			**1.05**	**3.67**
space heat	4.28					
water heat	0.61					
air conditioning	0.76					0.87
refrigeration	0.28					0.59
cooking		0.15				
lighting					1.05	2.21
Industrial total	**4.84**	**12.46**			**2.78**	**5.58**
process heat	4.84	12.46				0.33[3]
electric drive					2.34	4.14
electrolysis & other electrical					0.44	0.33[3]
Transportation total			**17.10**	**1.81**	**0.02**	**0.03**
autos, trucks, buses, aircraft, ships			15.42			
rail			0.58		0.02	0.03
other			1.10	1.81		
GRAND TOTAL	**19.49**	**13.23**	**17.10**	**1.81**	**4.37**	**13.49**
(% of total delivered enthalpy, 56.33 q)	(35)	(23)	(30)	(3)	(8)	—
(% of gross primary energy, 69.49 q)	(28)	(19)	(25)	(3)	(6)	(19)

[1] All these applications are assumed to be obligatorily electrical even though some are likely in practice to be readily substitutable, e.g., by gas mantle or solar lighting or compressed air drive.

[2] Assumed to be the drive (as opposed to heat) requirements.

[3] The 0.33 q of fossil fuel used to generate electricity at industrial sites is arbitrarily assumed to provide its output to "other electrical"; the exact mix is unknown.

SOURCE: Amory Lovins, **Soft Energy Paths**, Ballinger, Cambridge, MA, 1977

The following subtask descriptions provide a terse outline of the Oak Ridge residential simulation model, and the work necessary to adapt it to a Montana-specific analysis.

SUBTASK DESCRIPTION

Subtask 1. Simulation

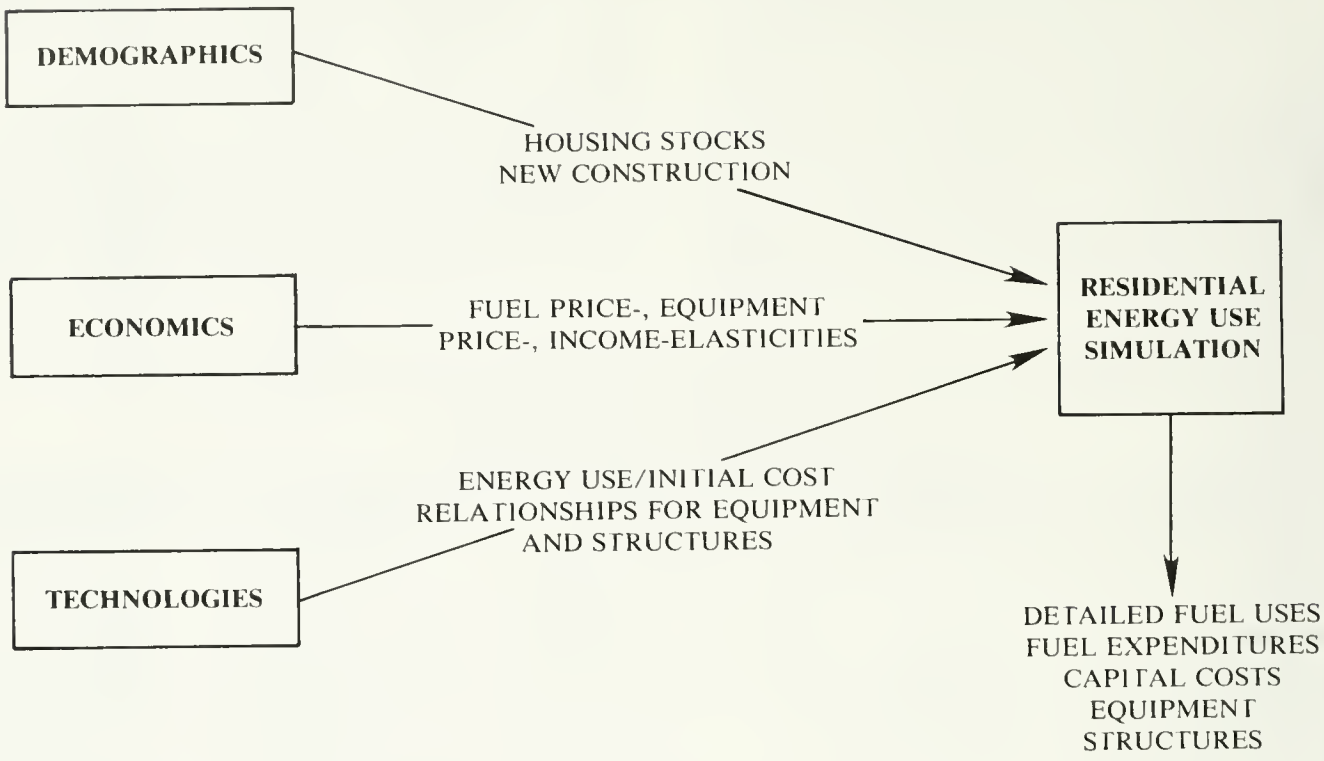
A basic schematic of the Oak Ridge model is provided in Figure 5. The various inputs are brought together in a simple multiplicative equation:

$$Q_t^{ikm} = HT_t^m \, HS_t^m \, C_t^{ikm} \, TI_t^{ikm} \, EU_t^{ikm} \, U_t^{ik},$$

(Sub and superscripts defined in following text.)

Where HT is the stock of occupied housing units, HS is the average size of housing units (for space heating and air conditioning only), C is the fraction (market share) of households with a particular type of equipment, TI is the thermal performance of housing units (for space heating and air conditioning only), EU is the average annual energy use for the type of equipment, and U is a usage factor.

Figure 5. Schematic of ORNL Residential Energy Use Model



SOURCE (Hirst and Carney, 1978)

The output of this equation includes 192 components: residential consumption of energy type i (electricity, natural gas, fuel oil and other) for end-use k (space heating, water heating, air conditioning, cooking, refrigeration, food freezing, lighting and other) in housing type m (single-family, multi-family and mobile homes) for each year t. The housing properties are determined by a housing submodel; the thermal integrity values are determined by a technologies submodel; and the appliance properties are determined by an economics submodel and the housing and technologies submodels (discussed in the following subtasks).

The computer program and a user's guide are available for the overall simulation; the major work involved lies in modifying the input parameters and submodels to make the simulation specific to Montana (subtasks 2 through 4 below). In addition, certain aspects of the model are being improved (e.g., market population); contact with the on-going Oak Ridge work is essential.

Subtask 2. Housing Submodel

The housing submodel performs three functions. The submodel projects the stock of each type of housing by estimating household head per seven age groups. This factor, referred to as the headship rate, and population estimates of each age group, yields the total number of households. The housing stock is then apportioned between each of the three housing types. A second function of the housing submodel is the estimation of new versus existing households in each year. This is accomplished by estimating household retirement (i.e. demolition and evacuation). Total housing stock, less household retirement, is the stock of new households. The third function of the housing submodel is to project the average size of each housing type.

In order to adapt the model to Montana, state-specific estimates of the housing stock and household retirement rates will have to be developed.

Subtask 3. Elasticity Estimator

The accuracy of the end-use simulation depends on the derivation of detailed price elasticities. In the Oak Ridge model, an overall price elasticity for a given fuel is derived from a separate econometric analysis (Cohn *et al.*, 1977). (The methodology in the latter is essentially identical to the Oregon approach discussed under Task 1).

The overall price elasticities are then broken into three separate residential responses to energy prices. Both own price and cross price elasticities are estimated for each end-use and for the consumer's response via each of: long run appliance market share saturation, short run use intensity (U), and long run appliance efficiency (EU). The last of the three occurs when consumers respond by improving the efficiency of their appliance stock.

The saturation elasticities are derived from a cross-sectional analysis of fuel choices for five end-uses. The appliance efficiency elasticities come from the technologies submodel (subtask 4 below) and a market penetration submodel that simulates the saturation of efficiency improving items. The use intensity elasticities are based on "engineering possibilities", which estimate the possibility of reducing the energy consumption of each end-use by altering use patterns, and judgments.

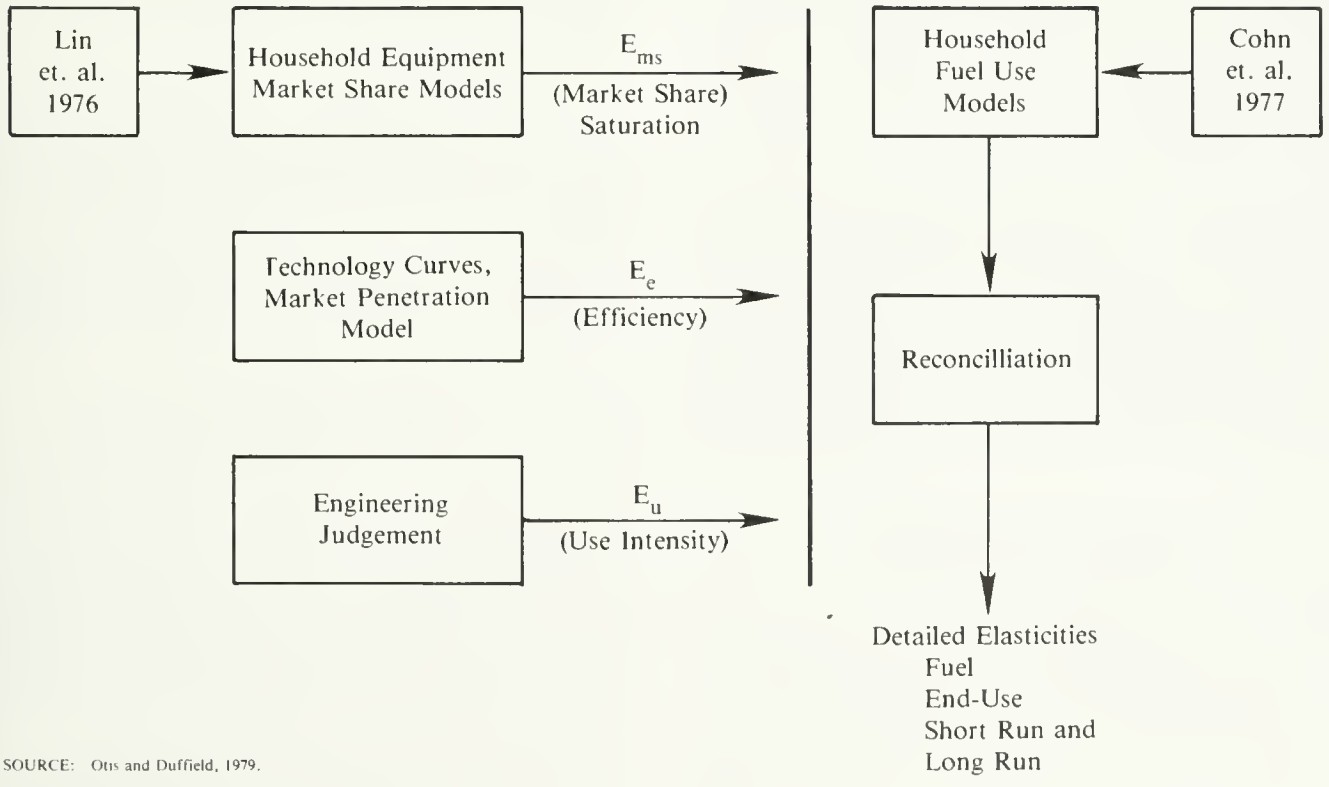
The sum of the detailed price elasticities are the total price elasticities. An iterative procedure is then used to compare the total elasticities with total elasticities (both short and long run) obtained from the separate analysis of residential electricity demand (Cohn *et al.*, 1977). The detailed elasticities are adjusted in response to the iteration, until the user is satisfied with their values relative to the total elasticity estimate. The income elasticity is estimated only in its total form from the Cohn *et al.* study. Figure 6 provides a summary of the elasticity derivation procedure.

The major work in this subtask is developing detailed elasticities consistent with Montana-specific total price elasticities.

Subtask 4. Residential Technologies

The technologies submodel contains the engineering aspect of the Oak Ridge model. Most of the work in this area will be done in the Technology Profiles element of the REV project. The capital cost/energy use tradeoff is required for input into the end-use simulation for the new or existing technologies being examined. Given energy prices and using this production function type of relationship, optimal or least cost technologies can be chosen. A number of appliance-specific studies have already been conducted by Oak Ridge and other researchers: space heating (O'Neal, 1978b), water heaters (Hoskins, 1977a), refrigerators (Hoskin, 1977b), and air conditioners (Papadopoulos, 1978). A solar space heating analysis is underway. Given the national homogenity of appliances, these studies can be efficiently utilized in this project.

Figure 6. Elasticity Derivation Procedure



SOURCE: Otis and Duffield, 1979.

TASK 4. OTHER END-USE

RESEARCH OBJECTIVE

The purpose of this task is to identify conservation and renewable energy alternatives in the commercial, industrial, transportation and agricultural sectors.

PRESENT STATUS OF RESEARCH

While end-use analysis is well developed for the residential sector (and to a lesser extent for transportation), comprehensive end-use analysis has not been generally applied to the industrial, commercial and agricultural sectors. There are basically two reasons for this. First, there is less reason to expect profit-maximizing firms to continue to overlook cost-effective energy sources or conservation alternatives. Given full information, businesses should already be doing this in their own self-interest. Secondly, unlike the residential sector which has a very limited range of end-uses, the agricultural and industrial energy uses and technologies (and to a lesser extent, commercial) are extremely varied, reflecting the spectrum of goods and services produced in this country. As a result, the modeling problem is much more challenging. Most of the effort in this task will be in constructing simple production functions that describe the energy/capital investment, input/output tradeoffs for Montana industry and agriculture. A basic strategy here is to identify the major energy users and focus on areas with the highest potential payoff, rather than attempting impossible-to-achieve comprehensiveness.

Some of the literature in this area is reviewed by Lovins (1977). A crude beginning on production functions for some Montana industries is found in MERDI (1976). Cross-sectional input/output information on industrial energy use has been developed by Clark Bullard and others at the Center for Advanced Computation at the University of Illinois. These sources will not be a substitute for industry (and in some cases, company) specific analysis in Montana.

SUBTASK DESCRIPTION

Subtask 1. Commercial End-Use

The commercial sector is most like the residential in terms of homogeneity of end-uses. In 1973, 85% of commercial energy use was for space heating and cooling; the remainder was largely water heating, refrigeration, lighting and cooking.

An engineering/econometric model will be analogous to the residential end-use model constructed for this sector (Jackson *et al.*, 1978). By developing a priority sequence in the modeling effort (highest payoff technologies first) a good approximation can be developed for this sector. First priority should probably be insulation, heat pumps and solar space heating technologies.

Subtask 2. Industrial End-Use

This sector contains the greatest diversity of technologies and end-uses. The major potential here is for increased efficiency in the use of conventional fuels and for substitution of renewable energy sources.

Since efficiency will be and has been motivated by higher fuel prices, a first cut at the "conservation" component should be based on price sensitivity identified in the industrial demand submodel of Task 1. A second cut would be to do a cross-sectional comparison of major Montana industrial energy users with other domestic or international companies (for example, Schipper, 1976). The third cut will be analysis of the production processes of actual Montana firms, perhaps on a sample basis.

The latter company-specific survey and analysis, plus end-use data from Task 2, plus evaluations from Technology Profiles will provide the basis for analysis of substitution of renewable energy sources.

Subtask 3. Transportation

The demand model for transportation (Task 1) is composed of four submodels: an estimate of electricity for lighting as a function of price and miles of streets; and separate equations for gasoline, diesel and jet fuel.

The electricity use can be decomposed into saturation, efficiency and use components for purposes of imposing higher efficiency and/or lower use intensity.

The gasoline demand submodel is already an engineering-econometric formulation, with price, miles driven (use), gallons per mile (efficiency) and autos/population (saturation) explicitly incorporated (Oregon, 1976a). This formulation (with input data on automobile stocks and retirement) allows explicit analysis of higher efficiency standards for automobiles, as well as price incentives (gasoline tax). Some effort will also be extended in this area to identify the potential market penetration of biomass fuels, and new technologies (electric cars). Results of other state-specific studies will also be utilized (Greene, 1978).

The diesel and jet fuel models could be recast in a similar way for analysis of efficiency improvements.

Subtask 4. Agriculture

There is a fairly extensive literature on energy use in agriculture, mainly at a fairly aggregated level (Lockeretz, 1977; Green, 1978). A recent analysis provides a national simulation model for identifying the effects of energy conservation strategies in agriculture (Levis *et al.*, 1977). The analysis here faces the same problems and approach outlined in Subtask 2, industrial: The price-sensitive model will capture some potential conservation effects, but output-specific analysis based on activity within the state (wheat, hay, etc.) will be necessary. The potential for use of renewables may prove to be very good in this sector due to its distributed low-intensity character.

TASK 5. SUPPLY MODEL

RESEARCH OBJECTIVE

The purpose of this task is to provide input to the demand model on energy prices and availability.

PRESENT STATUS OF RESEARCH

There has been a large number of state, regional and national studies examining the future supply of conventional fuels. A survey of this literature was recently completed for the Montana Department of Labor and Industry (Duffield, 1978). The future supply of some energy minerals, such as coal, is well understood. However, projections of future gas supply will need revision in light of recent Canadian discoveries and policy changes. There have also been a number of national studies that have estimated the availability and economic feasibility of renewables, specifically solar energy, for Montana and other states (Schulze, 1977; Balcomb, 1976; O'Neal, 1978a). The problem with the latter set of studies is that generally results for the state are based on analysis of a single site, such as Great Falls. Given the large variability in average solar radiation across the state (Duffield, 1979), results to date are only suggestive. There has been no comprehensive assessment of the potential for use of renewables.

SUBTASK DESCRIPTION

Subtask 1. Conventional Fuels

The major output of this subtask will be estimating future price and availability of conventional fuels: oil, coal, natural gas and petroleum. This information is an essential and critical input for the demand forecasting models which take price as an exogenous variable. It is expected that supply will be sufficiently elastic at the price "step" for any given future year for the exogenous price approach to be valid. This is certainly true for petroleum products, where price will be dominated by national and international markets and policies. The best estimates of petroleum prices will be derived from national sources such as Department of Energy and the Brookhaven National Laboratory.

The only area where availability and/or inelastic supply could be an important constraint is for natural gas. The literature in this area will be reviewed recent developments in Canadian export policy and Montana and Canadian gas exploration will be researched.

Subtask 2. Social Costs

Environmental controls are an important component of the costs of conventional fuels and electricity. Montana and federal environmental policy (specifically strip mining reclamation, emission standards for coal-fired plants, and the state's proposed new ambient air standards) will be examined for possible future modification of the input prices to be derived in Subtask 1.

While some environmental costs of conventional fuels are now internalized by policy measures and show up in end-use prices, two other "social cost" components need to be identified for this project. First is an estimate of the remaining environmental costs of using conventional (or renewable) fuels even if environmental standards are met. (For example, this could be an important constraint, and/or have implications for the feasible technology, in the use of wood for space heating.) Such estimates can be derived from the very large literature on environmental costs (see for example, the analysis for Montana in Otis *et al.*, 1978).

The second additional component of the "social cost" adjustment is correction for the historically large and continuing subsidies in fossil fuel production and conversion. For example, Brannon (1975) found that the tax benefit for oil and gas production was equivalent to 18% of the well head price. These adjustments are important in determining the full social cost of alternative energy strategies.

Subtask 3. New Fossil Fuel Conversion Technology

Subtask 4. Community-Scale Renewable Technologies

The purpose of these subtasks is to incorporate (into the supply/demand model) the information developed in the Technology Profiles element of the REV project. It is essential that new fossil fuel conversion technologies (such as coal gasification or liquefaction, fluidized bed combustion, and magnetohydrodynamics) be analyzed as substitutes for conventional technologies. The community-scale renewable technologies to be assessed should include wind, geothermal, on-site solar, biomass conversion, and small-scale hydro. The input from Technology Profiles will permit construction of energy use (or variable costs) vs. capital cost tradeoffs for each new renewable or fossil fuel technology.

Subtask 5. Land Use

An important preliminary finding of the California distributed energy study (DOE, 1978) is that land may be an important resource constraint for renewables. It is therefore essential to integrate a land use algorithm to ensure the consistency of projected residential (housing), industrial, and energy-related demands. The major work of this subtask will be in identifying the land use requirements of future technologies and in construction of a feedback mechanism for the overall simulation.

Subtask 6. Electric Production Cost

While yearly supply price may reasonably be taken as exogenous for most primary and end-use energy forms, this is not true for electricity. Historically, Montana's electricity supply has been dominated by low-cost hydroelectric generation. However, future additions to generating capacity will probably come from much more costly coal-fired generation, such as the proposed Colstrip #3 and #4 plants. As a result, the future price of electricity is very much a function of the quantity supplied. In addition, construction of a supply function (or production cost model) for electricity will permit accurate prediction of Montana specific prices. Given that electricity is the likely alternative for many of the renewable applications, accurate electric price forecasts are essential. (This, by the way, is a key failing of many of the national models (such as Schulze, 1977) that use average price increases for a region).

This subtask may possibly be undertaken by the state in developing its forecasting model. In any case, there is a large literature in this area (Ernst and Ernst, 1977). A production cost model compatible with the Task 1 demand model is being developed by the Oregon Department of Energy (Oregon Department of Energy, 1978a and b). The major steps in this analysis are: (1) estimation of the future generation mix and costs for generation, transmission, and distribution and (2) construction of a model of the state rate-making process (see Duffield, 1977).

Subtask 7. Price Feedback

For the electricity sector (and possibly for natural gas), a submodel will be constructed that searches for an equilibrium consumption and price path based on the supply and demand functions.

Table 7. Supply/Demand Element Timetable

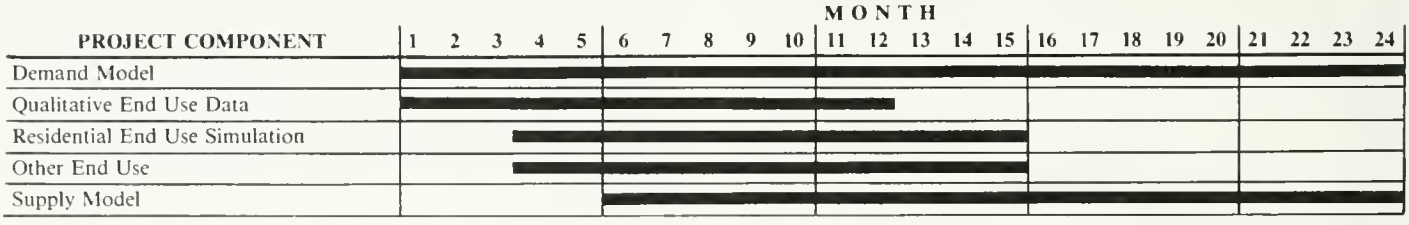

MONTH
PROJECT COMPONENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Demand Model
Qualitative End Use Data
Residential End Use Simulation
Other End Use
Supply Model

Table 8. Budget: Supply/Demand Element

	Year 1		Year 2		Total
Personnel					
Professional	1 FTE @ $20,000	$20,000	1 FTE @ $21,400	$21,400	$41,400
Support	1 FTE @ $13,000	13,000	1 FTE @ $13,910	13,910	26,910
Subtotal		**33,000**		**35,310**	**68,310**
Benefits (17%)		5,610		6,003	11,613
Personnel Costs		38,610		41,313	79,923
Travel		1,000		1,000	2,000
Computer		1,500		1,500	3,000
Printing		100		400	500
Other		—		—	—
Subtotal		41,210		44,213	85,423
Overhead (15%)		6,181		6,632	12,813
TOTAL COST		**$47,391**		**$50,845**	**$98,236**

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TECHNOLOGY PROFILES

The Montana Renewable Energy Viability Project (REV) is intended to examine the viability of renewable energy technologies and energy conservation for use in Montana. In the Technology Profiles element, specific technologies are identified, described, and critiqued. The purpose of this element is to develop sufficient information about the technologies to service other elements of the project. A technology profile differs from a technology assessment. The goal of the profile is to gather only sufficient information for its evaluation in the REV framework. By assembling strictly what is needed, rather than attempting to assemble everything that is known about a technology, the analytical effort is supported without overburdening the budget. Technologies about which little is known will be identified. The profile, then, will note unknown information and uncertainties.

The iterative aspect of REV requires the effective use of available information and the identification of information gaps. This framework for evaluating technologies will aid in the establishment of research priorities for Montana's alternative renewable energy R & D program and for Federal and private research and development. In the following pages the procedure for describing and evaluating technologies will be presented and followed by an identification and discussion of technologies to be studied.

PROCEDURE FOR DESCRIBING AND EVALUATING TECHNOLOGIES

The technologies under study must first be described. This description will be a "state-of-the-art" analysis of the technology using the most recently available information. It will be conducted through national information data bank searches, a review of current literature, manufacturer's surveys and personal contacts with experts in the field from academia, industry and the "grass roots." This information will be combined into a concise narrative report on each renewable technology or conservation option. Each of these reports will be able to stand alone. Each report will contain the information by which the technology can be evaluated; hence, they will be similar in scope and format. The generation report format follows:

Table of Contents: Typical Technology Profile

I. General Description
- A. Thermodynamic and engineering processes involved
- B. History and examples of applications
- C. Current and future availability

II. Performance Characteristics
- A. Energy output
  1. Quality - temperature, form
  2. Quantity
  3. Dynamics - daily, seasonal, annual
- B. Reliability
  1. Need for back-up
  2. Storage requirements
  3. Relationship to established transmission/distribution systems (e.g., electrical, gas)
- C. Thermodynamic efficiency
- D. Net energy

III. Costs
- A. Capital
- B. Assembly and installation
- C. Opération
- D. Maintenance and replacement
- E. Economies of scale
  1. Household
  2. Neighborhood/commercial/light manufacturing
  3. Community/industrial
  4. Regional/utility service area

IV. **Special Requirements and Impacts**
   A. Siting (directional aspect, land, height)
   B. Resource needs
      1. Renewable
      2. Conventional energy
   C. Construction and operating employment by skill
   D. Environmental residuals
   E. Health or safety aspects

V. **Summary and Critical Discussion**
   A. Cost per million BTU
   B. Resources, requirements, environmental residuals per million BTU
   C. Critical discussion of the technology
   D. Critical assessment of the state of information on the technology
   E. Recommendations for future research and development

VI. **Annotated References**

VII. **Reviewer Comments**

In applying the task format, each technology profile should be considered a separate task. Preparation of each section within that profile is a sub-task.

Task 1, 2, ..., n. Individual Technology Profiles

sub-task 1. general description. Here, the technology is described, including the thermodynamic and engineering processes involved, the range of applications in which it has been used or recommended for use, and its technical history. Examples of its application are presented. Availability for general use is another important aspect of the general description. Is the technology generally available in the marketplace? In a qualitative sense, it should be determined whether the technology is currently available (1980), as well as the likelihood of its being available in five, ten or twenty years.

sub-task 2. performance characteristics. The performance characteristics of the technology are described, including the characteristics of its energy output. The form of the energy output, such as heat, electricity, transportable liquid or gaseous fuels and so forth, should be identified. If the energy output is in the form of heat, then it will be described in terms of its temperature. The quantity of energy produced, as well as temporal variation throughout the day, the seasons and the year will be discussed. If performance characteristics are not linearly related to the size of the unit, then performance variations associated with size should be quantitatively discussed where possible.

Reliability of a renewable technology is an important aspect of performance, relating to whether the technology requires a back-up system, if it has particular storage requirements, or if it can be managed more effectively through the use of an existing gas or electric distribution system.

Researchers will evaluate efficiency of the technology, according to both the first and second laws of thermodynamics.

Net energy yield is defined as the difference between total energy delivered over the life of the system and energy required to produce and operate the system. It is a measure of the net contribution of the system as an energy supplier.

sub-task 3. costs. In order to make meaningful economic comparisons of various energy alternatives, it is essential to have a full and detailed understanding of the costs of those alternatives. The cost information developed will be consistent with assumptions and the analytical format of the supply/demand analysis. In the rational economic model, if characteristics other than cost, such as energy-produced and environmental effects, are the same, then the least cost alternative becomes the most economic alternative.

The profile will seek to provide best estimates of capital, assembly, installation, operation, maintenance and replacement costs for the candidate technologies. Furthermore, there will be an examination of possible economies associated with different scales of application.

sub-task 4. special requirements and impacts. Analysts of technology recognize that there are various associated requirements and impacts which enter into private and public decisions to deploy a technology. This sub-task provides important information for both the resource assessment and impact assessment elements.

Special siting requirements may exist, such as requiring a southern exposure and clear winter days. A technology may require a substantial surface area, or may need to extend some distance above the earth's surface. Such needs will be identified here.

Resource needs, such as solar radiation, wood, biomass, or wind will be identified in sufficient detail to permit analysis of the capability of Montana's renewable resource base, as described in the resource assessment element, to sustain the technology. Conventional energy requirements for pumping and forced draft circulation will also be identified and quantified.

As pointed out in the economic impacts section, the "pocketbook" issues of jobs and inflation have become increasingly important in public and private decision-making. Each technology will be discussed in terms of the employment effects associated with its deployment in Montana. The profile will include a discussion of construction, operating, and maintenance employment by skill level required.

Public health and safety hazards may be present with some renewable technologies. An example is high speed wind turbines in urban areas. Each technology will be examined from this perspective.

sub-task 5. summary and critical discussion. The various descriptive elements mentioned above will be expressed in terms of units per million BTU's produced. Thus, costs, resource requirements, environmental

residuals, jobs and so forth, can be expressed in a fashion which can be summed and compared with other technologies. The profile will contain a critical discussion of the technology in relation to possible application in Montana. Since most of the candidate technologies are in developing stages, the status of information will be critically discussed. Uncertainties must be noted. Recommendations for additional research and development, to strengthen the information base and reduce uncertainties, will be made.

sub-task 6. annotated references. The technology profiles will result in complete record of all sources of information identified during the development of each profile. Pertinent references will be cited, along with annotations as to the usefulness and credibility of various sources. Sources will include publications, experts, centers of technical expertise, and manufacturers.

sub-task 7. review comments. The information contained in each report will be verified and confirmed by independent peer review panels of national technical experts. Only reports where information has been verified in this manner will be acceptable for the evaluation process. The written review comments will be appended to each profile.

task n + 1. matrix of technologies. In addition to the report on individual technologies, this element will assemble a matrix of all candidate technologies containing evaluation criteria data. The evaluation criteria have been defined based on data requirements for the supply/demand analysis, impacts assessment, resource assessment and such other data as may be needed to fully evaluate the potential of a specific renewable energy technology or conservation opportunity for application in Montana.

TECHNOLOGIES TO BE STUDIED

In Figure 7 renewable energy sources, conversion processes and use forms are given for renewable energy sources appropriate to Montana. The broad technologies to be studied are solar, wind, biomass, hydropower and geothermal. These technologies concern themselves with processes and mechanisms for converting the primary solar (electromagnetic), wind (mechanical, kinetic), biomass (chemical), hydropower (mechanical, potential/kinetic) and geothermal (heat) energies into either heat (space heat, hot water, process heat), power (mechanical or electrical) or fuel (gaseous, liquid or solid). It is of interest to note that all the energy use forms presently derived from non-renewable fossil fuels (and uranium) are derivable from the renewable energy sources listed.

From Figure 7, there are 18 categories for which profiles will be developed. On the judgment of the REV team, some will be broken into sub-groups where appropriate.

Potential renewable energy and conservation options must be analyzed in relation to Montana's energy consumption patterns. As described in the supply/demand element, for this analysis energy consumption in Montana is broken down into five sectors as illustrated in Table 9. These sectors in turn are broken down into end-use categories. The agricultural sector includes only on-farm use. Off-site food processing is included in the industrial sector and farm homes are included in the residential sector. Municipal buildings (including schools), as well as county, state and federal buildings are included in the commercial sector. Conservation opportunities, since they are so directly linked to the end-use category, will be examined in a slightly different fashion. Working with the supply/demand researchers, the technology profiles researchers will first verify the inventory of conservation options. Following this, the options will be ranked in terms of potential energy savings and cost-effectiveness. Those at the top of the list will be profiled in a fashion similar to the renewable technologies.

The end uses (thirty-four in number) will be matched with potential renewable energy and conservation options. This matching process will be presented in a matrix format. Renewable energy and conservation options for each of the five sectors are described briefly in the following.

RESIDENTIAL ENERGY SECTOR (R)

End use categories in the residential energy sector are residential space heating (R_1), residential space cooling (R_2), residential water heating (R_3), residential lighting (R_4), residential appliances (R_5) and residential food storage and preparation (R_6). There are renewable energy technologies and conservation options in this sector appropriate to individual residences and to communities. These are separately enumerated in Table 10. The technologies for implementation of most of the energy and conservation options of this sector exist and have demonstrated viability at a number of sites in this country and throughout the world.

Figure 7. Renewable Energy Sources, Conversion Processes and Use Form

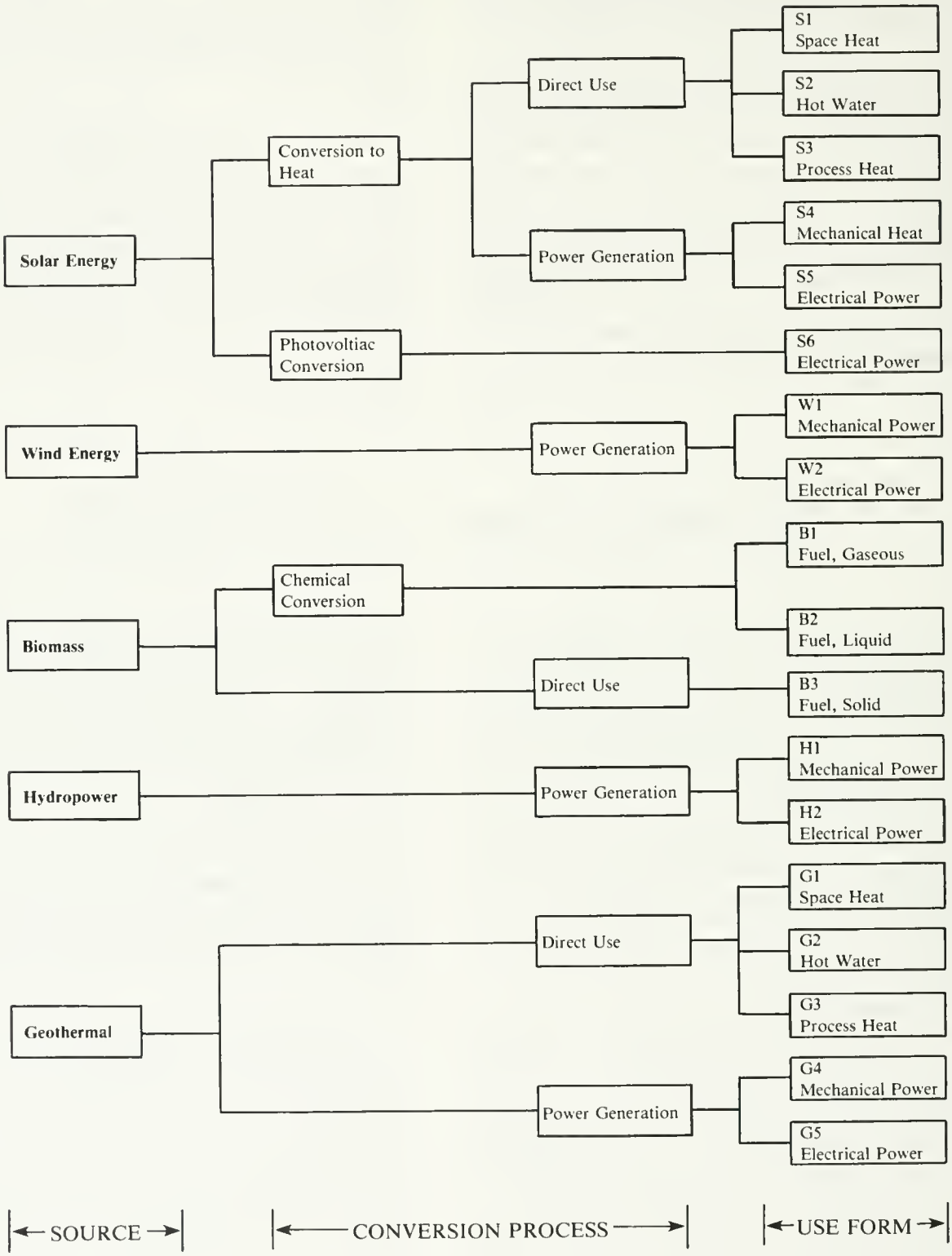
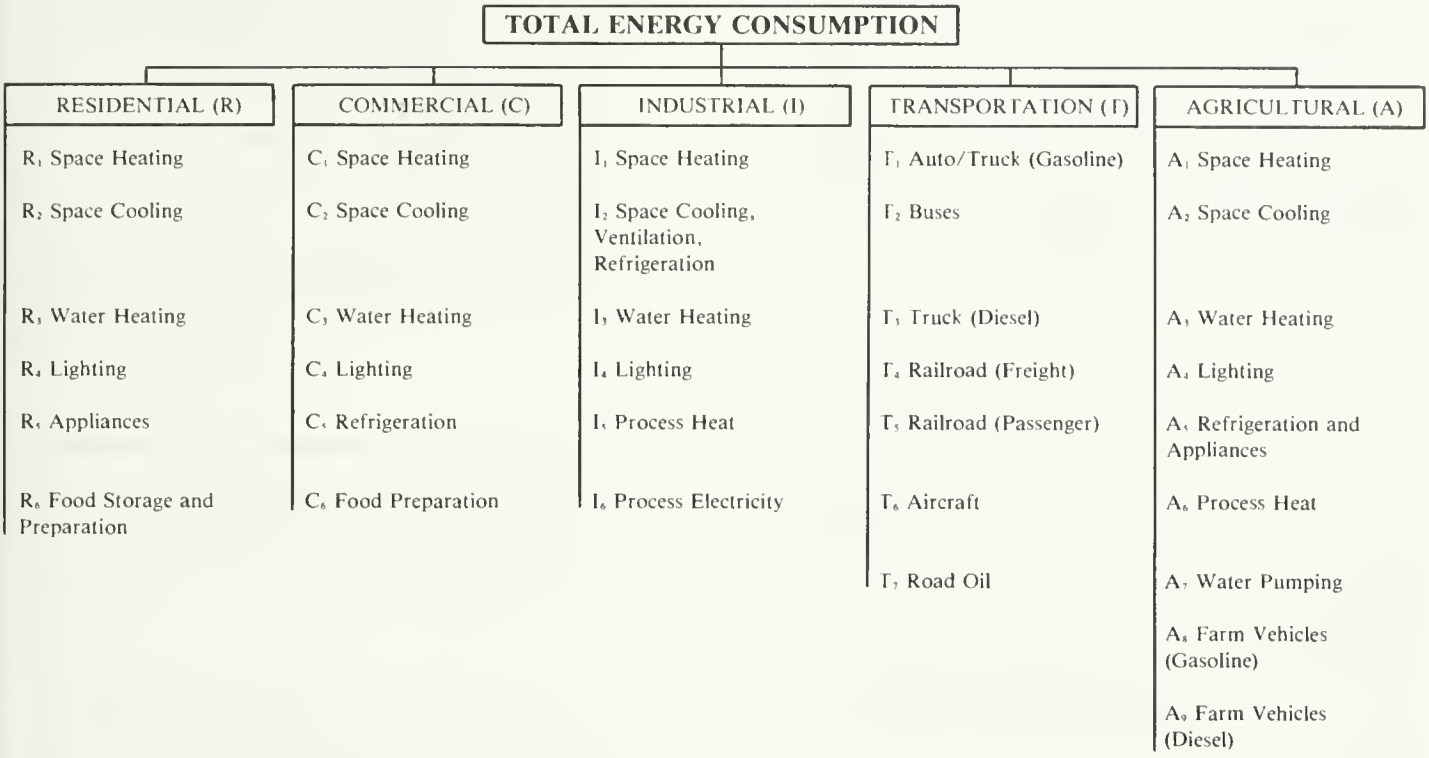


Table 9. Total Energy Consumption End-Use Sectors and Categories



Residential Space Heating (R_1)

individual structure: Commercial and owner-built active solar heating systems, both for new construction and retrofit of existing structures are currently in use in a broad spectrum of climatic conditions. Active solar system require electrical energy input for pumping water and/or air and, in general, require a back-up energy system. In contrast, passive solar systems take advantage of natural energy flows, requiring no supplementary energy. Passive solar architecture coupled with biomass combustion possesses the potential of providing 100% of annual space heating energy for properly designed new structures. Passive retrofit and solar greenhouses can contribute significantly to the space heating energy requirement of existing residential structures, as can wind in certain applications.

Conservation options include weatherization, fans for air circulation, furnace efficiency improvements and lifestyle modifications. Weatherization can significantly decrease energy consumption for space heating and should be top priority in any energy conservation program. Significant energy saving can also be achieved by installation of low rpm ceiling fans for circulating warm air downward from the ceiling. Lifestyle changes, in particular, use patterns which reduce waste of energy, must be explored and encouraged.

community: Liquid and gaseous fuel generation from biomass represents a possible source of space heating energy for Montana communities. The source of the required biomass consists of agricultural waste, biomass crops, and forest residue. The community use of geothermal energy where available will be considered, as will annual energy storage systems.

Where available and appropriate, industrial waste heat can be used for residential space heating. Direct combustion of residential and commercial refuse at a central location could provide energy for space heating and also represent an opportunity for metals and other materials recycling. District heating can be considered in the proximity of a thermal power plant or other industrial heat source.

Heat storage is a key aspect of the performance of solar space heating systems, and must be carefully planned.

Residential Space Cooling (R_2)

individual structure Residential space cooling energy requirements in Montana are less (on a per-residence or per-capita basis) than in most other states, but nonetheless should be considered in a residential energy use analysis. These energy requirements can be provided by commercial solar air conditioning equipment, by wind, photovoltaic or hydropower generation of electrical power for ventilating and cooling appliances, and by passive design cooling both for new structures and retrofit.

Table 10. Renewable Energy and Conservation Options — Residential Sector

End Use	Renewable Energy Option	Conservation Options
Residential Space Heating	**Individual Structure:** Commercial active solar, new* Commercial active solar, retrofit** Owner-Built active solar, new* Owner-Built active solar, retrofit Passive Solar, new Passive Solar, retrofit Solar greenhouse Direct Combustion, solid biomass **Community:** Geothermal Fuel generation (liquid, gas) from biomass	**Individual Structure:** Weatherization Furnace Efficiency Improvements Fans, air circulation **Community:** Industrial waste heat utilization Direct combustion, residential and commercial refuse
Residential Space Cooling	**Individual Structure:** Commercial solar air conditioning Wind generation of electrical power Photovoltaic generation **Community:** Electric generation-biomass combustion Central solar electrical power generation Geothermal electric generation	**Individual Structure:** Appliance efficiency improvement Lifestyle modification Fuel switching Venting, passive and active Weatherization **Community:** Improved efficiency - central station electric generation Direct combustion, residential and commercial refuse, for electrical generation
Residential Water Heating	**Individual Structure:** Commercial active solar Owner-Built active solar Direct combustion-biomass Biogas generation **Community:** Geothermal Fuel generation (gas, liquid) from biomass	**Individual Structure:** Fuel switching Appliance efficiency improvement Insulation retrofit Lifestyle modifications Water restrictive showerheads **Community:** Industrial waste heat utilization Direct combustion, residential and commercial refuse
Residential Lighting	**Individual Structure:** Wind generation Photovoltaic conversion **Community:** Central station solar electric generation Central station biomass electric generation Central station geothermal electric generation	**Individual Structure:** Efficiency improvements Natural lighting, skylights, etc. Lighting standards Lifestyle changes **Community:** Lighting standards Generation/distribution Efficiency improvements Lifestyle changes
Residential Appliances	**Individual Structure:** (Same as Residential lighting above) **Community:** (Same as Residential lighting above)	**Individual Structure:** (Same as Residential lighting above) **Community:** (Same as Residential lighting above)
Residential Food Storage and Preparation	Solar cookers Solar ranges	Lifestyle changes Efficiency improvements Natural refrigeration

*On New Structures **On Existing Structures

Conservation options include weatherization, venting (both passive and active), switching to more abundant fuels and improvement of efficiency of cooling appliances. Lifestyle modifications, in particular in terms of demands and use patterns, are important in this context.

community Community scale electric power generation using solar, geothermal, biomass combustion and hydropower is a renewable energy option for electrical power supply for all community electrical power requirements including residential space cooling. The technical viability of community scale electric power generation has been or is in the process of being demonstrated at various sites.

Community scale conservation options consist of efficiency improvements of electrical power generation and distribution and the production of primary heat for electrical power generation by the direct combustion of commercial and residential refuse. This second option, again, represents an opportunity for metals and other materials recycling.

Residential Water Heating (R_3)

individual structure: The technical and economic viability of solar systems for residential hot water has been demonstrated. Solar heating of residential water is a technology which could be implemented on a large scale. Both commercial active solar systems and owner-built active systems have demonstrated effectiveness. Direct combustion of biomass and/or biogas generation can provide the back-up for solar systems or themselves be used as primary sources. Wind power also has potential here.

Conservation options include appliance efficiency improvement, insulation retrofit of heaters and distribution pipes, and water restrictive showerheads. As with space heating and space cooling, lifestyle modifications in demands and use patterns are important in this context.

community The use of geothermal energy and biomass fuel generation are community scale energy options. Community scale conservation options include industrial waste heat utilization and direct combustion of residential and commercial refuse.

Residential Lighting (R_4)

individual structure Electrical lighting is the most efficient form of artificial lighting available. Wind generation, photovoltaic conversion and hydropower generation of electrical power represent technologically feasible renewable energy options. Efficiency improvements of lighting fixtures and contexts, and maximiation of natural lighting (consistent with efficient space heating) are two important conservation options. Light intensity in lighting standards could be significantly relaxed without imparing lighting effectiveness, probably to the benefit of the user. Lifestyle modification in use patterns and demands also represents an important conservation option.

community Community scale electric power generation as an alternative to regional scale generation/distribution, is an increasingly attractive option for providing electrical supply for small and medium sized communities (up to 100,000). Solar energy, wind energy, biomass combustion energy, geothermal energy and hydropower are potential sources of community scale electric power generation. Conservation options include improvement of efficiency of generation and distribution, lighting standards and lifestyle changes as indicated above.

Residential Appliances (R_5)

individual structure:
(same as R_4 above)

community:
(same as R_4 above)

Residential Food Storage and Preparation (R_6)

individual structure Food preparation and storage techniques and patterns which have evolved over the past several decades (during the era of abundant, inexpensive fossil fuels) require substantial energy input. American agriculture has become the world's most energy intensive agricultural system. It is estimated that nearly ten calories of primary (fossil fuel) energy are required to put one calorie of food energy on a typical American plate. Part of this energy is used in storing and preparing food in the home. The combined energy use of a typical electric range and frost-free refrigerator may be as high as one-fourth of the total household electrical energy use. Because of the temperatures involved in cooking, it is difficult, without some change in food preparation. However, solar cookers, solar ranges (with high temperature storage), solar ovens and solar food dryers have been demonstrated to be technically viable. Biomass combustion and biogas generation on an individual home scale are also viable renewable energy options.

Consideration will be given to food storage and preparation patterns for implementation of both renewable energy and conservation options.

community Community scale fuel (liquid, gaseous) from biomass is a renewable energy option for provision of energy for food storage and preparation. A conservation option is the improvement of efficiencies of electrical power generation and distribution.

COMMERCIAL ENERGY SECTOR (C)

End-use categories in the commercial energy sector are commercial space heating (C_1), commercial space cooling (C_2), commercial water heating (C_3), commercial lighting (C_4), commercial refrigeration (C_5) and commercial food preparation (C_6). The renewable energy and con-

servation options for this sector are enumerated in Table 11. Technologies for implementation of most of the energy and conservation options of this sector exist and have been demonstrated at a number of sites in this country and throughout the world.

Commercial Space Heating (C_1)

The renewable energy options for commercial space heating are similar to those for residential space heating. Both passive and active solar systems can contribute significantly to the energy required for space heating. The incorporation of passive solar architectural concepts and active solar systems into the initial design of a building can provide up to 95% of the annual heat energy for the building. Active and passive solar retrofit to existing commercial structures also can provide a high percentage of the heat energy required for maintenance of the internal environment. Direct combustion of biomass, use of available geothermal energy and fuel generation from biomass are all possible options and will be considered.

Table 11. Renewable Energy and Conservation Options-Commercial Sector

End Use	Renewable Energy Options	Conservation Options
Commercial Space Heating (C_1)	Commercial active solar, new Commercial active solar, retrofit Onsite active solar, new Onsite active solar, retrofit Passive solar, new Passive solar, retrofit Direct combustion of biomass Geothermal Fuel generation (Liquid, Gas) from biomass	Weatherization Furnace efficiency improvements Fans, air circulation Industrial waste heat utilization Direct combustion, residential and commercial refuse Lifestyle changes
Commercial Space Cooling (C_2)	Commercial solar air conditioning Wind generation of electric power Photovoltaic generation of electric power Biogas generation Central station biomass combustion-electric generation Central station solar electric generation Geothermal electric generation	Weatherization Appliance efficiency improvements Improved efficiency electric generation/distribution Lifestyle modification Fuel switching
Commercial Water Heating (C_3)	Commercial active solar Local built active solar Direct combustion-biomass Biomass fuel generation Geothermal	Appliance efficiency improvements Insulation retrofit Lifestyle modification Fuel switching Industrial waste heat utilization Direct combustion, residential and commercial refuse
Commercial Lighting (C_4)	Wind generation of electric power Photovoltaic conversion Central station solar electric generation Central station biomass electric Central station geothermal electric generation Intermediate size hydropower electric generation	Natural lighting; skylights, etc Lighting standards Efficiency improvements of fixtures/units Efficiency improvements of electrical generation/distribution Lifestyle changes
Commercial Refrigeration (C_5)	Central station solar electric generation Central station biomass electric generation Central stations-geothermal electric generation Photovoltiac conversion Wind generation Fuel generation from biomass Hydropower generation	Efficiency improvements of appliances/units Efficiency improvements of electrical generation/distribution Fuel switching Lifestyle changes
Commercial Food Preparation (C_6)	Solar food processors Biomass fuel generation Wind generation of electric power Photovoltaic generation of electric power Central station solar electric generation Central station geothermal electric generation Central station biomass combustion/electric generation Community scale hydropower electric generation	Appliance efficiency improvements Efficiency improvements of electrical generation/distribution

Weatherization of existing structures, furnace efficiency improvements and use of fans for air circulation are conservation options that could be implemented widely. Industrial waste heat use and direct combustion of residential and commercial refuse are also viable conservation options. As in the residential sector, behavior patterns evolved during the past several decades (during the era of abundant, inexpensive fossil fuels) will probably have to be changed. For example, an energy audit of a typical supermarket (with open refrigeration, windowless and excessively artificially lighted) would yield a variety of immediate and near term energy conserving modifications, requiring minor lifestyle adjustments.

Commercial Space Cooling (C_2)

Same as R_2 above

Commercial Water Heating (C_3)

Same as R_3 above

Commercial Lighting (C_4)

Same as R_4 above

Commercial Refrigeration (C_5)

Commercial refrigeration requires electrical power, which may be provided from central station renewable energy by solar electric generation, biomass electric generation, geothermal electric generation, wind generation, photovoltaic conversion and hydropower. The use of biomass fuel for generation will be investigated for possible application in this end use category.

Conservation options include efficiency improvements of appliances and refrigeration units, efficiency improvements of electrical generation and distribution and switching to more abundant fuels. Lifestyle changes, in particular in demand and use patterns, are important potential conservation areas.

Commercial Food Preparation (C_6)

This category includes only those improvements which prepare and sell food directly to the public. Solar food processors are a renewable energy option for the commercial preparation of food. Solar ranges with high temperature storage have been shown to be technologically feasible. The use of fuel (liquid, gaseous) generated from biomass also is a viable renewable energy option in this category. Electric power for food preparation can be supplied by wind generation, photovoltaic generation and/or central station (solar, geothermal, biomass, hydropower) generation.

Options for conservation include optimization of use patterns, appliance efficiency improvements and efficiency improvements of electric generation and distribution.

INDUSTRIAL ENERGY SECTOR (I)

A large number of opportunities exist for the significant utilization of renewable energy in the industrial energy sector are: Industrial Space Heating (I_1), Industrial Space Cooling, Ventilation and Refrigeration (I_2), Industrial Water Heating (I_3), Industrial Lighting (I_4), Industrial Process Heat (I_5) and Industrial Process Electricity (I_6).

Industrial Space Heating (I_1)

Space heating of industrial offices, shops and production facilities does not differ significantly from space heating of commercial facilities. The renewable energy options and conservation options for industrial space heating are as discussed in C_1 above. Lifestyle modification to implement use and demand pattern changes and conservation measures are important and will be investigated in this context.

Industrial Space Cooling, Ventilation and Refrigeration (I_2)

Except for the possibility of differences in scale, the renewable energy options and conservation options in this category are the same as R_2 and C_5 above. In addition, the concept of co-generation (use of waste heat for electrical generation) will be investigated.

Industrial Water Heating (I_3)

See C_3 above

Industrial Lighting (I_4)

Renewable energy options and conservation options in the industrial sector are similar to those in the commercial sector C_4 above. In addition, the concept of co-generation will be investigated.

Industrial Process Heat (I_5)

Several solar systems for producing industrial process heat are in operation in the United States. Others are in the design or early construction stages. Their technological viability is established and such systems in coming decades will contribute significantly to the nation's energy income. Process hot water, steam and hot air can be readily generated using solar energy. Other renewable energy options for process heat generation are direct combustion of biomass, biomass fuel generation and geothermal.

Conservation options include process efficiency improvements, waste heat utilization and fuel switching.

Table 12. Renewable Energy and Conservation Options-Industrial Sector

End Use	Renewable Energy Options	Conservation Options
Industrial Space Heating (I_1)	Commercial active solar, new Commercial active solar, retrofit Onsite active solar, new Onsite active solar, retrofit Passive solar, new Passive solar, retrofit Direct combustion of biomass Geothermal Fuel generation (liquid, gas) from biomass	Weatherization Furnace efficiency improvements Fans, air circulation In-Plant waste heat utilization Local waste heat utilization Direct combustion, residential and commercial refuse Lifestyle change
Industrial Space Cooling, Ventilation Refrigeration (I_2)	Commercial solar air conditioning Passive design, new and retrofit Photovoltiac generation of electric power Wind generation of electric power Central station solar electric generation Central station biomass electric generation Central station geothermal electric generation Fuel generation from biomass Hydropower electric generation	Weatherization Fans, air circulation Appliance efficiency improvements Improved efficiency, electric generation/distribution Lifestyle changes Co-generation
Industrial Water Heating (I_3)	Commercial active solar Local built active solar Direct combustion, biomass Biomass fuel generation Geothermal	Appliance efficiency improvements Insulation retrofit In-Plant waste heat utilization Local industrial waste heat utilization Direct combustion, residential and commercial refuse
Industrial Lighting (I_4)	Wind generation of electric power Photovoltaic conversion Central station solar electric generation Central station biomass electric generation Central station geothermal electric generation Hydropower generation of electrical	Natural lighting; skylights etc Lighting standards Efficiency improvement of fixtures/units Efficiency improvements of electrical generation/dist. Lifestyle changes Co-generation
Industrial Process Heat (I_5)	Commercial active solar Local built active solar Direct combustion, biomass Biomass fuel generation Geothermal	Process efficiency improvements Waste heat utilization (recycling, recuperation) Fuel switching
Industrial Process Electricity (I_6)	Wind generation Photovoltaic generation Central station solar electric generation Central station biomass electric generation Geothermal electric generation Hydropower electric generation	Process efficiency improvements Improved efficiency, electric generation/distribution Co-generation

Industrial Process Electricity (I_6)

It is technologically feasible to generate electrical power for industrial use by wind generation, photovoltaic conversion, as well as central station solar, biomass combustion, geothermal, and hydropower electric generation. This is possible in scale from multi-megawatt facilities to multi-kilowatt installations. Conservation options include process efficiency improvements, improved efficiency of electric generation and distribution and use of local waste heat for generation of electrical power (co-generation).

TRANSPORTATION ENERGY SECTOR (T)

Renewable energy options and conservation options in the transportation sector are listed in Table 13. They are Auto/Truck, Gasoline (T_1), Buses (T_2), Trucks, Diesel (T_3), Railroad, Freight (T_4), Railroad, Passenger (T_5), Aircraft (T_6), and Road Oil (T_7). Transportation energy use in the United States has been the subject of a variety of studies. The basic conclusions of these studies are that:

I. The national trend for several decades has been (and remains) toward the most energy intensive transportation modes (aircraft, individual auto, trucks) from the least energy intensive modes (bicycles, trains, buses).

II. Implementation of conservation means such as rapid transit, improved and increased rail utilization, individual auto use minimization, and improved efficiency of all modes of transportation are a rational necessity.

III. Alternate fuels for transportation must be found.

Table 13. Renewable Energy and Conservation Options-Transportation Sector

End Use	Renewable Energy Options	Conservation Options
Transportation, Auto/Truck, Gasoline (T_1)	Biomass fuel generation (liquid) Photovoltaic generation-electricity Central station solar electric generation Central station geothermal electric generation	Efficiency improvements - new Efficiency improvements - retrofits Gasahol Fuel switching - diesel Lifestyle alteration Use pattern optimization Use minimization Effective rapid transit
Transportation Buses (T_2)	Biomass fuel generation Photovoltaic generation electricity Central station solar electric generation Central station geothermal electric generation	Efficiency improvements - new Efficiency improvements - retrofit Lifestyle alteration Use pattern optimization
Transportation Trucks, Diesel (T_3)	Biomass fuel generation	Efficiency improvements - new Efficiency improvements - retrofit Use pattern optimization
Transportation Railroad (Freight) (T_4)	Biomass fuel generation	Efficiency improvements - new Efficiency improvement - retrofit Use pattern optimization
Transportation Railroad, Passenger (T_5)	Biomass fuel generation	Efficiency improvements, new Efficiency improvements, retrofit Use pattern optimization Lifestyle modifications Use maximization Electrification
Transportation Aircraft (T_6)	Biomass fuel generation	Efficiency improvements, new Efficiency improvement, retrofit Use pattern optimization Lifestyle modification
Transportation Road Oil (T_7)		Process efficiency maximization

Electric trains, buses, trucks and automobiles are feasible (in particular for short runs) and the electrical energy can be derived from renewable energy sources. Liquid fuel can also be generated from biomass. These are the two renewable energy options available for implementation in the transportation sector.

The implementation of a variety of conservation options could reduce significantly the energy demand in the transportation sectors. These options include efficiency improvements of new and existing transportation equipment, use pattern optimization, lifestyle modifications, maximization of low intensity modes and minimization of high intensity modes.

AGRICULTURAL ENERGY SECTOR (A)

The nine end-use categories in the agricultural energy sector are: Agricultural Space Heating (A_1), Agricultural Space Cooling (A_2), Agricultural Water Heating (A_3), Agricultural Lighting (A_4), Agricultural Refrigeration and Appliances (A_5), Agricultural Process Heat (A_6), Agricultural Water Pumping (A_7), Agricultural Vehicles, Gasoline (A_8) and Agricultural Vehicles, Diesel (A_9).

Agricultural Space Heating (A_1)

Agricultural buildings can be heated with passive and active solar heating systems. New structures can be designed to include both passive solar architecture and active systems and existing structures can be retrofitted with both passive and active systems. Solar heating systems should be able to provide between 70% and 90% of the heating energy for agricultural buildings. The direct combustion of biomass, and the generation of fuel from biomass are also renewable energy options appropriate to this category. In some locations in the state, geothermal energy may also be found useful for heating agricultural buildings.

Weatherization is a very important conservation option. The improvement of the efficiency of existing heating units, the use of fans for circulating, utilization of waste heat and use pattern optimization are other conservation options to be considered.

Agricultural Space Cooling (A_2)

The cooling of agricultural buildings, where required, can be accomplished using renewable energy as discussed in (I_2) and (C_2) above. Similarly, conservation options are the same as in (I_2) and (C_2) above.

Agricultural Water Heating (A_3)

Commercial active solar and locally built active solar systems may be used for producing hot water for agricultural use. Direct combustion of biomass, biomass fuel generation and geothermal energy are other options. Use pattern optimization, insulation retrofit and appliance efficiency improvements are conservation options to be investigated.

Agricultural Lighting (A_4)

See C_4 above.

Agricultural Refrigeration and Appliances (A_5)

See R_5 and C_5 above.

Agricultural Process Heat (A_6)

See I_5 above.

Agricultural Water Pumping (A_7)

Several large scale (20 - 50 hp) solar water pump facilities are in operation in the United States with others in initial design or construction stages. The technological viability of solar powered irrigation water pumping has been well demonstrated. Using wind power for water pumping has been done for centuries and recent years have seen significant improvements in design and fabrication of windmills. Small scale central station solar electric generation (as well as wind generation, biomass combustion generation, geothermal generation) and biomass fuel generation are other renewable energy options for agricultural water pumping.

Conservation options in agricultural water pumping include process efficiency improvements, use pattern optimization, fuel switching and improvement of efficiency of electric generation and distribution.

Agricultural Vehicles - Gasoline (A_8)

See Transportation, Energy Sector (T) above.

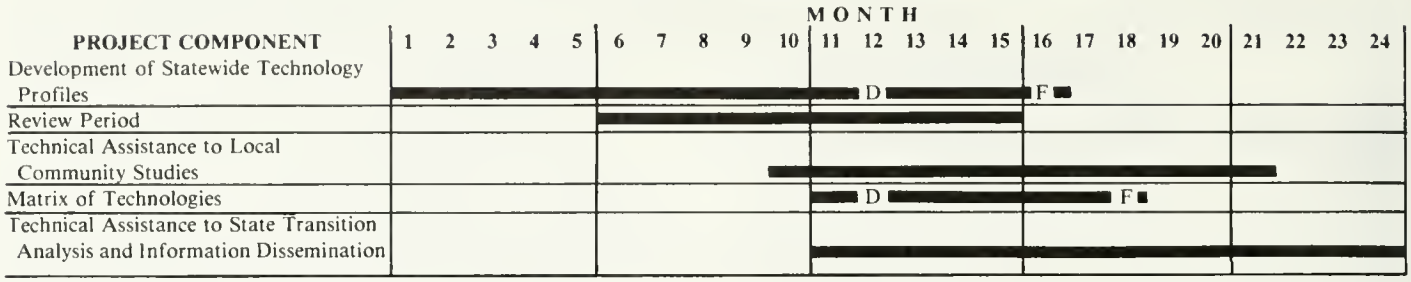
Agricultural Vehicles - Diesel (A_9)

See Transportation, Energy Sector (T) above.

Table 14. Renewable Energy and Conservation Options-Agricultural Sector

End Use	Renewable Energy Options	Conservation Options
Agricultural Space Heating (A_1)	Commercial active solar, new Commercial active solar, retrofit Onsite active solar, new Onsite active solar, retrofit Passive solar, new Passive solar, retrofit Direct combustion of biomass geothermal Fuel generation (liquid, gas) from biomass	Weatherization Furnace efficiency improvements Fans, air circulation Use pattern optimization Waste heat utilization
Agricultural Space Cooling (A_2)	Commercial solar air conditioning Wind generation of electric power Photovoltiac generation of electric power Biogas generation Central station biomass combustion-electric generation Central station solar electric generation Geothermal electric generation	Weatherization Appliance efficiency improvements
Agricultural Water Heating (A_3)	Commercial active solar Local built active solar Direct combustion - biomass Biomass fuel generation Geothermal Wind	Appliance efficiency improvements Insulation retrofit Use pattern optimization
Agricultural Lighting (A_4)	Wind generation of electric power Photovoltaic conversion Central station solar electric generation Central station biomass electric generation Central station geothermal electric generation Hydropower generation	Natural lighting, skylights etc. Efficiency improvements of fixtures, units Efficiency improvements of electrical generation/distribution
Agricultural Refrigeration and Appliances (A_5)	Central station solar electrical generation Central station biomass electrical generation Central station geothermal electric generation Photovoltaic Conversion Wind generation Fuel generation from biomass Hydropower generation	Efficiency improvement of appliances/units Use pattern optimization
Agricultural Process Heat (A_6)	Commercial active solar Local built active solar Direct combustion, biomass Biomass fuel generation Geothermal	Process efficiency improvements Waste heat utilization (recycling, recuperation) Fuel switching
Agricultural Water Pumping (A_7)	Solar irrigation water pumps Windmill - pumps Small scale central station solar electric generation Biomass fuel generation Geothermal electric generation Wind energy electric generation Biomass combustion electric generation	Process efficiency improvements Use pattern optimization Fuel Switching Improvement of efficiency of electric generation/distribution
Agricultural, Vehicles, Gasoline (A_8)	Biomass fuel generation	Efficiency improvements Gasahol Fuel switching Cropping-pattern changes Use pattern optimization
Agricultural Vehicles, Diesel (A_9)	Biomass fuel generation	Efficiency improvements Use pattern optimization Cropping pattern changes

Table 15. Technology Profiles Element Timetable


MONTH
PROJECT COMPONENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Development of Statewide Technology Profiles
D
F
Review Period
Technical Assistance to Local Community Studies
Matrix of Technologies
D
F
Technical Assistance to State Transition Analysis and Information Dissemination

D = Draft F = Final

Table 16. Budget: Technology Profiles Element

	Year 1		Year 2		Total
Personnel					
Professional	1 FTE @ $20,000	$20,000	1 FTE @ $21,400	$21,400	$ 41,400
Support	1 FTE @ $13,000	13,000	.5 FTE @ $13,910	6,955	19,955
Subtotal		**33,000**		**28,355**	**61,355**
Benefits (17%)		5,610		4,820	10,430
Personnel Costs		38,610		33,175	71,785
Travel		2,500		2,500	5,000
Computer		——		——	——
Printing		750		750	1,500
Other					
Consultants - peer review panels (90 days @ $150.00/day)		8,750		4,750	13,500
Subtotal		50,360		40,925	91,285
Overhead (15%)		7,554		6,139	13,693
TOTAL COST		**$58,164**		**$47,314**	**$105,478**

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RESOURCE ASSESSMENT

A. INTRODUCTION

1. NEED FOR A RENEWABLE ENERGY RESOURCES ASSESSMENT

Montana's total annual energy consumption is equivalent to about 50 million barrels of oil. This can be compared with the potential for utilizing renewable energy resources. The solar energy falling on 25 square miles in Montana (0.017% of the State's land area) has an energy content greater than 50 million barrels. A thousand board-feet of lumber is roughly equivalent in energy content to three barrels of oil. If four cubic feet of methane can be derived from each pound of man's solid waste, Montana's population annually rejects wastes equivalent to about 200,000 barrels. The animal population of the state produces additional waste. It is apparent from these numbers that renewable energy resources have important potential, notwithstanding that to be put to broad use any form of energy must meet various public and private tests, including cost-effectiveness, environmental effects, reliability, and public acceptability.

Energy resources like coal, oil and natural gas may not be strictly non renewable; nature is probably producing them at its own pace. That pace is so slow, however, that man is using up the resources far faster than they are being produced. A resource is considered "non-renewable" whenever it is being used significantly faster than it is being created by nature. Solar energy is renewable, because it is replaced every day the sun shines. Wind energy is solar heat that has been converted to mechanical energy by the environment. Hydropower resources are replaced on a regular annual basis. Since a forest can be replaced after a few decades, wood can be managed as a renewable resource. Biomass that can be converted to useful fuel is a by-product of life itself. Geothermal energy may not be strictly renewable (it originates from radioactive decay), but man does not appear likely to come close to causing a global impact on this vast resource. Thus, geothermal energy will be taken to be renewable.

Non-renewable resources in Montana will be assessed by the State Department of Natural Resources and Conservation (DNRC). Only renewable energy resources will be assessed in the work proposed herein. In the following discussions of this proposed task, the term "resource" will be "renewable energy resource" unless explicitly defined otherwise.

As an aid to both public and private planning it is important to understand the potentials for use of each identified resource.

2. OBJECTIVES

The availability of certain resources at particular sites is directly influenced by micro-climates, land-forms, vegetation patterns and other factors. There is no intention to develop new state-wide site-specific resource information through this element. It will provide generalized area-specific information upon which reasoned judgments can be made as to the potential at specific locations. It will produce the most complete and detailed assembly of renewable energy resource information for the appraisal of renewable energy development potential in a general region and estimates of resource availability in the absence of monitoring. Future research and data gathering priorities will be recommended.

The specific objectives are:

(a) to gather pertinent existing information on the magnitude of renewable energy resources in the state. This will include assembling data generated by ongoing resource monitoring projects and assessing the data for accuracy where possible. Fulfilling this objective must include specification of key parameters necessary to characterize each resource;

(b) to identify important gaps in the information, fill the gaps where possible and recommend procedures for data improvement where necessary;

(c) to put the information in a form suitable for defining spatial and temporal resource distribution; and

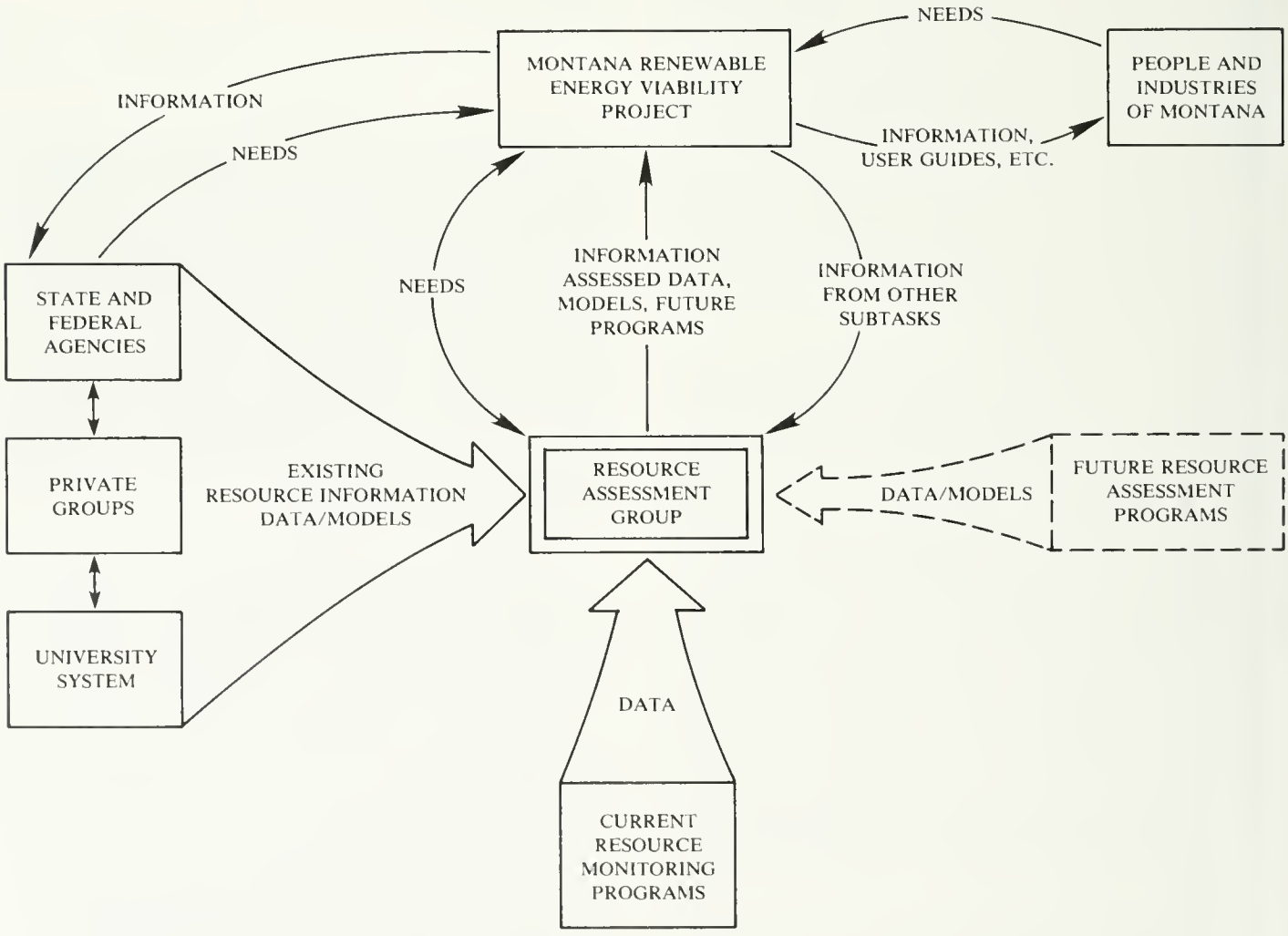
(d) to distribute the information to DNRC, other interested government agencies, REV personnel and the general public. Information will generally be in the form of maps, narrative reports and graphs for distribution to government agencies and REV staff. Information for the general public will be condensed to shorter bulletin forms.

3. GENERAL METHODOLOGY

In order to accomplish these objectives, the Resource Assessment team will interact with REV project personnel and other agencies and individuals throughout the state as shown in figure 8. The diagram exhibits the primary information flows. This information will be in the form of raw data (in), assessed data (out), available resource models (in), and developed models (out). The assessed data will be supplied to other REV elements and used by the team to develop descriptive resource models. The "needs" information flows are shown in the flow diagram and represent identified information needs from or for the team.

The team will include personnel responsible for data assessment and verification, model development update and verification, and for the development of future programs to fill identified resource data gaps. All data gathered will be verified for accuracy by comparisons with known standards. The data handling framework will utilize for input the assessed and verified data of the key parameters for each resource and will estimate the statewide potential from the partial resource data. This space-time distribution of resource potential will be one of the determining factors for the success of the overall project. If, as anticipated, data gaps appear in any of the resources, then proposals can be made to fill these gaps. The details of the methodology for each resource are presented in the tasks which follow.

Figure 8. Information flow diagram illustrating the functions of the resource assessment group



B. TASKS

The resources that have been selected for study by the project are: solar, geothermal, wind, hydro, wood, and biomass. Since each resource is unique there will be a separate task for each resource. Despite their uniqueness, effort will be made to make each task as similar as possible, particularly in the methodologies. In general, each resource will be assessed in terms of its potential end-uses. This is necessary since the type of data needed can vary with the application of the resource. For example, the direct component of solar radiation is needed for high temperature applications, such as power generation, while the total component is necessary for low temperature space heating applications. It should also be noted that some of the resources may be included under more than one task. For example, paper could be recycled (conservation) or it could be burned for fuel (biomass). It is not an objective of the resource assessment to determine how these resources are to be used; therefore, each resource must be considered where appropriate. The separate tasks follow.

1. SOLAR ENERGY ASSESSMENT TASK

(a) Overview

Solar energy, in its broadest sense, can be defined as radiant energy produced by the sun's thermonuclear reactions. Total radiation on a horizontal surface has two components: direct beam radiation and diffuse radiation. Direct beam radiation is the radiation which comes directly from the sun and diffuse radiation strikes the earth's surface after it has been scattered by the atmosphere.

Several end-uses can be identified for solar energy. These are: space heating, space cooling, water heating, power generation, and drying. In Montana, the major end uses would most likely be space heating, power generation in the summer months, irrigation, and crop drying. These end-uses require year round solar radiation data. The power generation and space heating applications require knowledge of both the direct and diffuse components of solar radiation. Typical power generation schemes require high temperatures produced by concentrating collectors. This type of collector will effectively utilize only direct beam radiation. Both components of solar radiation are used in space heating where both active and passive space heating applications are considered.

Until recently, there have been only three reliable solar radiation monitoring stations in Montana: Glasgow, Great Falls and Summit. Total solar radiation data for these locations are available from the National Oceanic and Atmospheric Administration (NOAA) in Ashville, North Carolina. Recent estimates have been made of total radiation on a horizontal surface using cloud cover data (Cinquewani *et al.*, 1978). Cloud cover is an hourly estimate, which is made by a trained observer, of the percentage of the sky that is covered by clouds. Although a formal evaluation of this type of data has not been found, a representative of the Solar Energy Research Institute (SERI) indicated that this data would be accurate to with ± 20 percent (Warrington, 1979). The cloud cover data are available for seven additional locations in Montana: Billings, Cut Bank, Dillon, Helena, Lewistown, Miles City and Missoula. Two other sties which have begun solar monitoring programs in Montana are Butte, at the National Center for Appropriate Technology (NCAT) and Bozeman, through the Engineering Experiment Station at Montana State University. All of these monitoring stations are shown in Figure 9.

Another possible source of radiation data is Fowlkes Engineering. These data are obtained using solar cell instruments placed in high schools throughout the State. An effort will be made to verify these data before they are considered.

All of the solar radiation data currently available represent total horizontal radiation. These data can be converted to direct beam data and to data on a tilted surface using established techniques found in the literature (Duffie *et al.*, 1974; Kreith and Kreider, 1978); Liu and Jordan, 1960; and Liu and Jordan, 1963).

(b) Sub-tasks

The sub-tasks of this task are to:

(i) gather and verify existing solar radiation data (This includes the cloud cover data which has been manipulated to yield an expression of available solar radiation.)

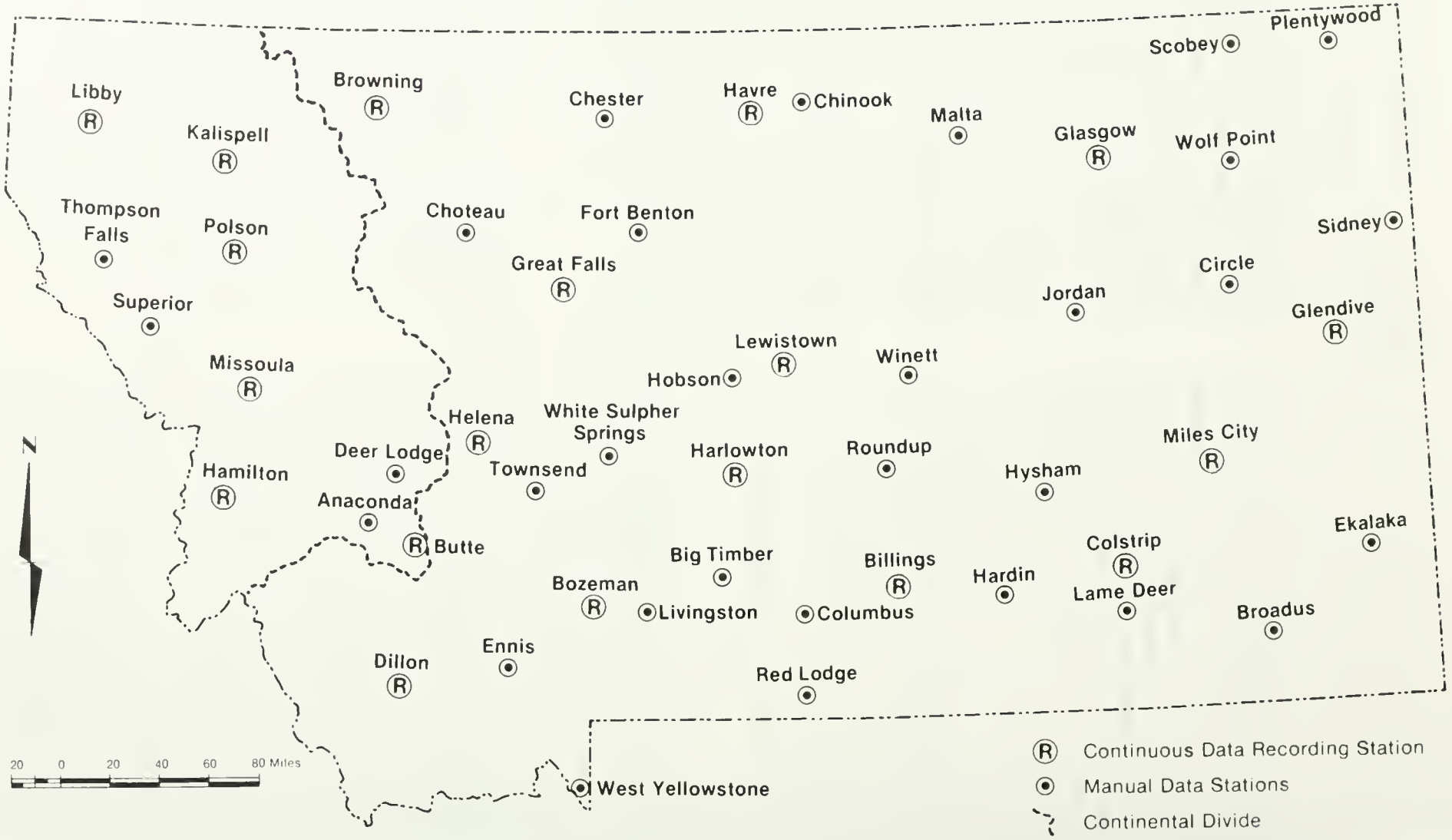
(ii) gather existing cloud cover data from all meteorological stations in Montana and convert to solar radiation data.

(iii) develop a simple analytical model which will describe the space-time variation of solar radiation.

(iv) idenfity data gaps and propose methods for acquiring needed information.

(v) develop solar resource information suitable for distribution to the government and citizens of Montana.

Figure 9. Solar insolation monitoring stations



2. METHODOLOGY

The solar data assembled from the sources mentioned above will be verified and stored for use in the model. Additional cloud cover information will be obtained and used to estimate solar radiation.

The model will use the above data to determine the yearly maximum, average and minimum solar radiation for locations in Montana for which the data are available and the maximum and minimum values for the best and worst years, respectively, for solar radiation over the interval in which the data were taken (typically greater than four years). The maximum and minimum values will enable confidence intervals to be made for solar designs at these locations. Another function of the analysis will be to estimate values for locations without solar radiation data.

In addition to gathering and verifying solar radiation data, a cloudy/clear day factor will also be obtained for each location in Montana with cloud cover data. It has been shown that the duration of cloudy/sunny days significantly affects the performance of solar heating systems, particularly passive (Warrington, 1979). This cloudy/clear day factor, which takes into account the number of consecutive clear/cloudy days, will also be compiled for the best, average and worst years for each location.

The data and model discussed above will be verified and modified as needed. They will be updated over the life of the project and used to identify existing gaps in solar radiation data. The analysis will also consider changes in microclimate due to pollution.

The projected subtask results and information output will include: monthly solar intensity and cloudy/clear day factor maps for the state; proposals for filling data gaps; consultative input to REV; user guides; and bulletins.

3. GEOTHERMAL ENERGY ASSESSMENT TASK

(a) Overview

Geothermal resources may be classified into three types: hot dry steam, a mixture of steam and hot water in varying portions and hot dry rock. Geothermal energy has basically the same end uses as solar energy. Depending on the temperature of the energy source, geothermal energy could be used for electrical power generation, industrial/agricultural process heat or space heating. According to a 1967 estimate, Montana has 17,920 acres of federally owned land which is known to be geothermally valuable (Berman, 1975).

Geothermal energy in the state is currently being assessed by DNRC, the United States Geological Survey and the Montana Bureau of Mines. According to these sources, there are no geothermal sites in Montana that have been identified as suitable for electrical power generation (Warrington, 1979). There are only six areas which are classified as wet steam. They are West Yellowstone, Corwin Springs, Hunters' Hot Springs, Marysville, Winston and Barkell. The rest of the known geothermal potential is hot liquid of varying temperatures. The locations of these sources are shown in Figure 10.

The hot dry rock potential in Montana is largely unknown (Warrington, 1979). The Marysville geothermal project did explore the hot dry rock potential of this area. The test hole went to about 7,000 feet with temperature at that depth near 200°F. The project was abandoned as having little potential for economic electrical power generation (McSpadden, 1974). To justify the expense of drilling a test hole (– 10,000 ft) to assess the hot dry rock potential of a site, an exceptional heat flow anomaly in a convenient setting would be required (McSpadden, 1974). These conditions do not appear to exist in Montana and without a substantial decrease in the cost of drilling a test hole, which might be obtained from laser drilling technology, the hot dry rock potential in Montana will not be assessed in the foreseeable future (McSpadden, 1974).

For the purpose of this task, the geothermal resource assessment will focus primarily on the wet steam and hot liquid resources with end uses such as industrial/agricultural process heat and space heating. One potential for more data in this area is a possible change in the petroleum lease option agreements (McSpadden, 1974). The new lease agreement would require the test hole to be logged for flow rates and temperature versus depth data. In addition, it would require the well casing to be left in place to a certain depth. If the laws were so changed it would generate a considerable amount of geothermal data and leave potentially usable sites.

(b) Sub-tasks

The sub-tasks of this task are to:

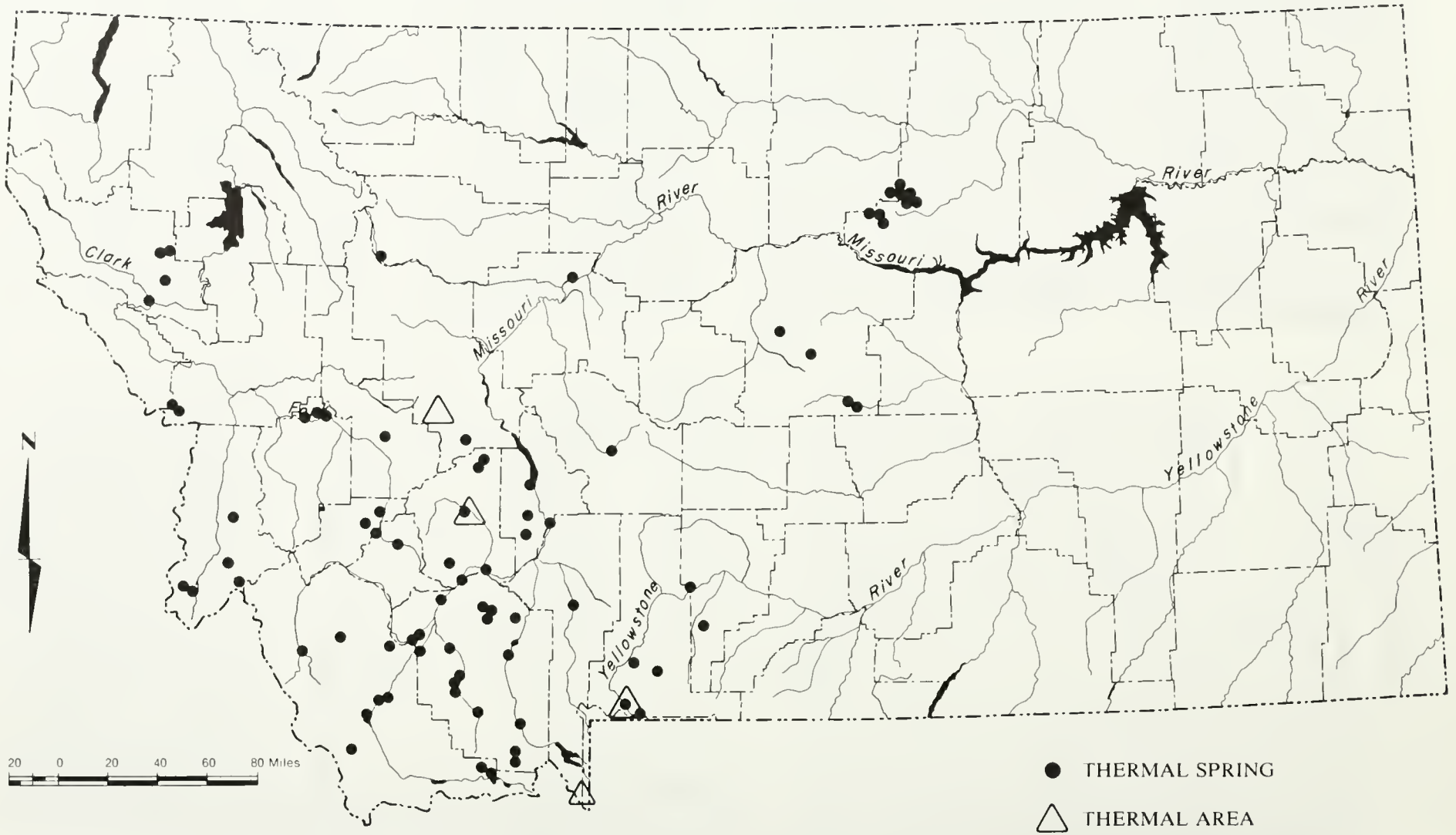
(i) gather existing geothermal energy resource data and update them over the life of the project.

(ii) develop a simple analytical model which will take the temperature/flow rate data and determine the availability of energy at each site.

(iii) analytically simulate the performance of the geothermal site with different usage scenarios.

(iv) develop geothermal resource information suitable for distribution to the government and citizens of Montana.

Figure 10. Geothermal sites pinpointed across Montana



(c) Methodology

Existing data will be obtained from the sources discussed above. With the temperature/flow rate data, the availability of energy at each site can be assessed. In addition, at sites where estimates of the size of the geothermal source are available, the task will estimate the time-performance of the site based on different usage scenarios. These scenarios will depend on the proximity of potential users. For small scale/low temperature use of geothermal energy, the distance between users and source is important and the analysis must account for this.

Information from the task will be distributed to interested agencies and individuals. This information will be primarily in the form of site specific geothermal maps listing potential energy rates. Time history data will also be made available for the different usage scenarios.

4. WIND ENERGY ASSESSMENT TASK

(a) Overview

Wind energy is solar energy that has been converted to kinetic energy by the environment. This energy form does not lend itself to transportation to the prime converter, and thus inherently involves distributed systems technology. The technology tends to be capital intensive, however, and detailed time dependent wind speed data are necessary before the viability of a proposed wind energy installation can be assessed. The objective of this task is to make such detailed information available for various possible sites in Montana. This information, together with information gathered by the technology profile element will permit planning for future wind energy utilization.

Montana's low population density may lend itself to use of a distributed resource such as wind. The most natural application of wind energy is pumping water. The water is easily stored for later use for livestock, irrigation, industrial process or cooling, or household use. The most often advocated application of wind energy is electrical power generation. Relatively large wind energy conversion installations for electrical generation and/or water pumping should only be considered for sites with reliable and strong wind. Thus, this task should include not only wind speed data for the entire state to assess wind as a distributed resource, but should also include identification of special sites which show promise for employment of larger wind energy conversion installations.

The most comprehensive single source of data is the work by Reed (1975). This publication lists monthly average wind speed ranges (percent of time wind speed is in each of the specified ranges) for fourteen different locations in Montana. The locations are indicated in Figure 11. The publication also gives monthly and yearly averages of wind power from one location. These data show wide variations in wind power from one location to another. For example, annual power averages range from 50 w/m^2 in Missoula to 500 w/m^2 in Livingston. The data also exhibit large temporal variations of, for example, from 234 w/m^2 average in June to 1059 w/m^2 in December in Livingston.

Reed's data list is not adequate as a complete resource assessment. Variations between nearby locations can be very large. The wind power average at Great Falls International Airport exceeds the wind power average at Malmstrom Air Force Base by 80 percent even though those locations are only about ten miles apart. Microclimatic conditions can vary rapidly from point to point in mountainous regions. Brelsford (1979) is conducting a detailed wind energy measurement study in the Livingston area. The effects of local geomorphology on wind patterns and intensities were reported by Duchon (1975) and Marwitz and Marrs (1975). The techniques presented in these last two references can be used to estimate detailed wind variations from point to point in a region such as Livingston. These estimations can then be compared with and refined from data such as Brelsford's.

Upper air wind velocity data are presented by Crutcher (1959). Such data can be combined with geomorphic data given in topographical map form available through the U.S. Geological Survey to develop models to estimate local wind conditions. Ground wind speed data not published by Reed can be obtained from the Weather Bureau and NOAA.

(b) Sub-tasks

The sub-tasks of this task are to:

(i) gather data which would be necessary to forecast the performance of a wind power installation at various locations in Montana.

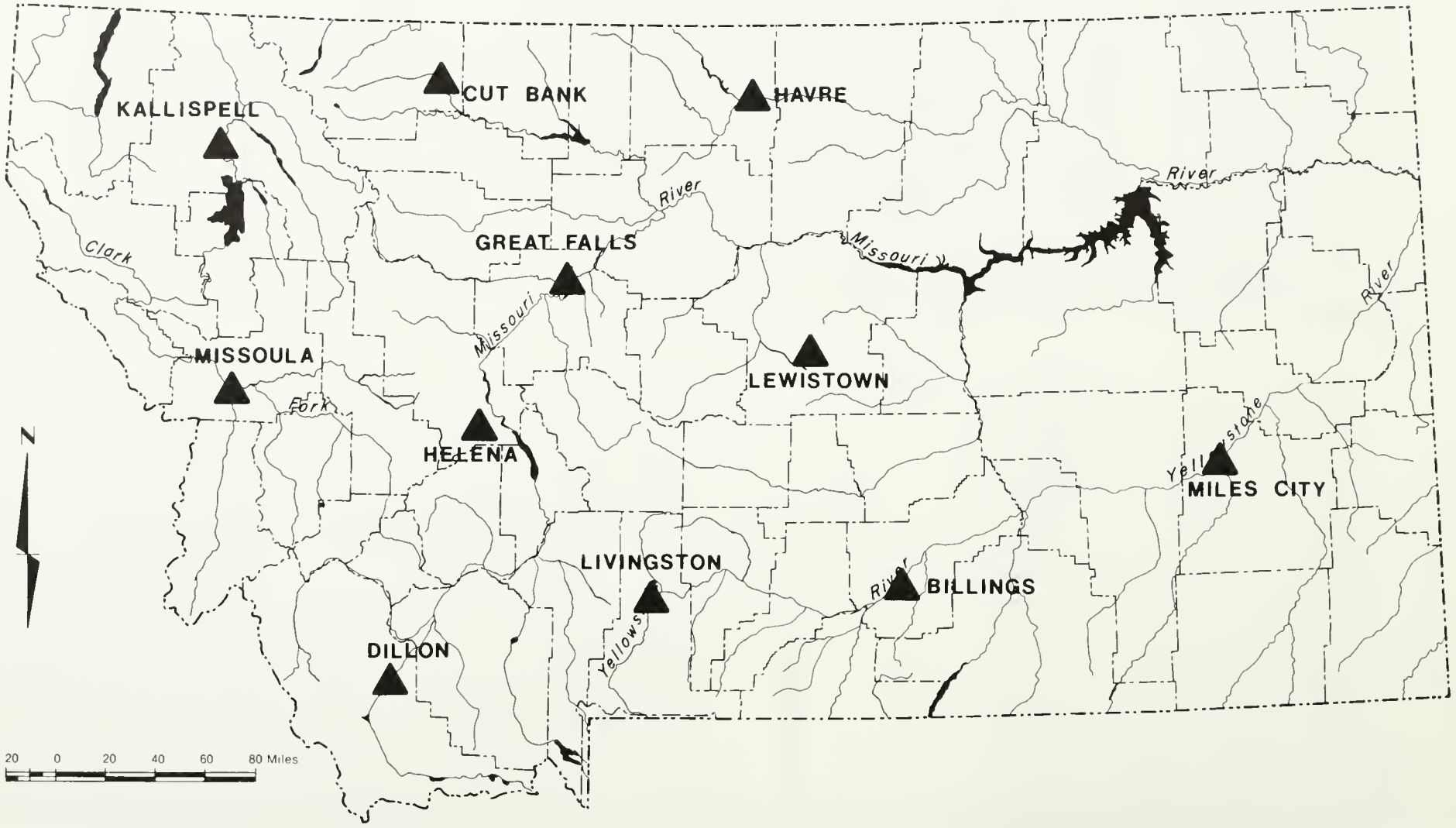
(ii) generate a simple model which estimates the resource intensity throughout Montana at any time of the year and identify locations with particularly strong and reliable winds.

(iii) verify and modify the model as necessary and identify pertinent gaps in the available data.

(iv) prepare output information in a form suitable for distribution to government agencies, the general citizenry and to staff of the technology profile element.

(v) identify methods for filling data gaps that might still remain.

Figure 11. Locations for Wind Speed Data in Montana



(c) Methodology

Pertinent numerical data assembled from the various sources will be stored in machine readable form suitable for processing by the analytical model. The model will describe spatial and temporal variations in wind power density throughout Montana. In its simplest form, the model will simply interpolate between locations where data are available. Subsequent more sophisticated forms of the model will use local geomorphic data to add rational fluid mechanical prediction theory to the interpolation procedure. Results from this procedure will be compared with Brelsford's detailed field data to validate and modify the model as necessary. The model should include a confidence interval as well as the best estimate of wind power intensity for specific locations.

The verified mode will then be used to help identify selected locations which appear particularly suitable for wind energy conversion. Such locations might include mountain tops and ridges, mountain passes and canyons with intense and consistent winds.

Information from the analysis will be transmitted to government agencies and the general public in the form of monthly isodyn maps. Information identifying selected locations will be transmitted to DNRC in narrative and graphical report form. All information will be transmitted to the technology profile element staff.

5. HYDROPOWER ASSESSMENT TASK

(a) Overview

Hydropower development represents a significant source of sustainable energy. Much of the total hydropower potential within the State of Montana has been developed into large and medium scale hydroelectric generating facilities as shown in Figure 12. A significant amount of hydropower potential still remains essentially undeveloped. As of 1976, Montana's hydroelectric nameplate capacity amounted to 1,879 megawatts and with completion of the Libby Dam facilities the total was raised to 2,345 megawatts (Clack, 1976).

Untapped potential hydropower resources can possibly be utilized on a small to medium scale for individual or community use. Approximately 41 major state water conservation projects have dammed facilities (Water Resources Division, 1977). These projects will be examined for possible use of their available hydropower. At present, the State of Montana is considering three state-owned dams as possible sites for hydroelectric power generation (Tudor Engineering Company, 1978).

Hydropower potential is characterized by two parameters, the total head or water elevation above the generating device and the water flow rate. Elevation changes in the area of a potential site and surface water flow rates into the area are needed to assess the amount of this resource available. Extensive topographical and long-term seasonal drainage information for the entire State of Montana is currently available. This information will facilitate the assessment of unused hydropower potential in the State.

The utilization of this resource on a medium scale is dependent upon the energy demand of nearby communities. The assessment of medium scale potential sites will include consideration of the population near the sites. Utilization of these hydropower resources will involve the construction of dams and the reservation of land for water storage. Small scale individual use of hydropower is dependent on the individual's access to a stream flow. Potential sites for this use will be examined.

(b) Sub-tasks

The sub-tasks of the hydropower task are to:

(i) review existing information on stream flows for various drainages in Montana. This includes population distributions near sites and topographical and flow rate data.

(ii) compile information necessary to broadly assess the potential power generation of existing dams not designed for hydropower usage.

(iii) develop a simple model which will describe the distribution and power potential of possible hydropower sites. This will include estimates of the temporal variations of potential power from these sites.

(iv) determine the gaps which might exist in the input information and propose methods for filling those gaps.

(v) develop the findings in a form suitable for distribution to the government and citizens of Montana.

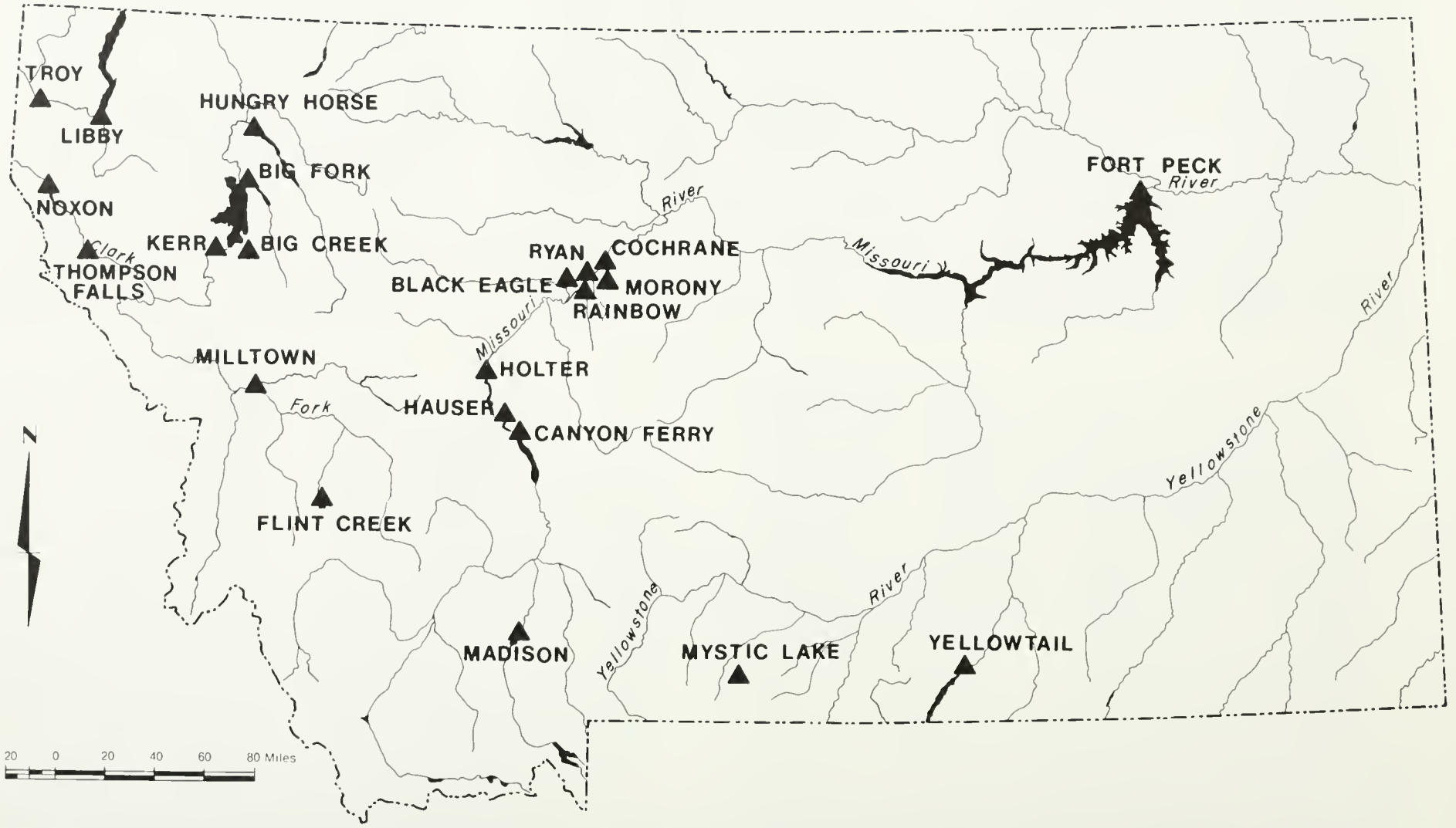
(c) Methodology

Several state and federal agencies have information on Montana water and land resources which will be utilized in assessing the undeveloped hydropower resource in the state. Since the size of potential individual hydropower locations may be small, the analysis will be carried out with regard to nearby population centers. This task will involve working very closely with officials from the U.S. Geological Survey and the Montana Department of Natural Resources, Water Resources Division.

Potential sites will be assessed on the basis of stream flows and elevation differences. The potential for increased large-scale hydroelectric capacity will not be examined.

Potential sites will be located on maps. The potential power supply and the area population will be included on the maps so that the resource can be considered in relation to potential demand.

Figure 12. Existing hydroelectric generating dam sites in Montana



6. WOOD ENERGY ASSESSMENT TASK

(a) Overview

Wood is a potential energy resource and can be managed as a renewable resource. The State of Montana contains over 20 million acres of forest lands which are predominantly located in the western regions of the State (U.S. Department of the Interior, 1964). The map in Figure 13 displays these forested areas. Forest lands are individually under the control of either State or Federal agencies or private land owners.

The natural cycle of growth and death in a forest creates a significant amount of wood potentially available as an energy source. This natural cycle produces dead timber in two categories: standing dead and downed. Commercial utilization of selected areas of Montana forest lands supplies Montana's lumber and paper industries. Logging generates a large volume of wood waste in the forest, known as slash, which is either left on the logging sites or burned to decrease the insect and fire hazard within the forest. It has been estimated that 13 million tons of slash are generated within Montana's commercial forest areas every year (U.S. Forest Service, 1971). This forest debris represents a theoretical maximum of the energy equivalent of 33 million barrels of oil. Addition of the quantities of standing dead wood and downed timber in Montana results in a significant resource.

Regular surveys of Montana's forested areas are carried out by both state and federal agencies. These surveys are performed for selected forests in order to update the forest management strategy of a particular area. The information contained in these surveys includes estimates of the quantities of live and dead timber (U.S. Department of Agriculture, 1977).

The lumber industry also generates significant amounts of wood wastes in the form of sawdust and wood chips. Much of this potential energy source is utilized in allied wood product industries, although the volume of waste generated is often not fully utilized.

(b) Sub-tasks

The sub-tasks of this task are to:

(i) assemble data necessary to assess the potential of wood energy in the State.

(ii) develop a simple model which will describe the spatial and temporal availability of these resources.

(iii) identify areas which might be managed for wood energy production.

(iv) make this information to DNRC, REV personnel, other government agencies and the general public.

(c) Methodology

An assessment of potential wood energy resources is to be obtained by assembling data compiled by major wood-related agencies and industries. These sources include slash, standing dead and down timber, live timber and industrial wood wastes. Heat values of Montana wood types will also be obtained.

The model will be used to describe the spatial and temporal variation of the wood resource subject to the constraint that utilization rates will not exceed resource replacement rates. Areas identified as potential forest area will be considered. Output will include the average annual available energy from known wood resources.

Once the basic analytical framework has been established, gaps which may exist in the input data can be identified and means suggested for rectification. If necessary, wood resource maps will be compiled for the state showing known and potential resources.

7. BIOMASS ENERGY ASSESSMENT TASK

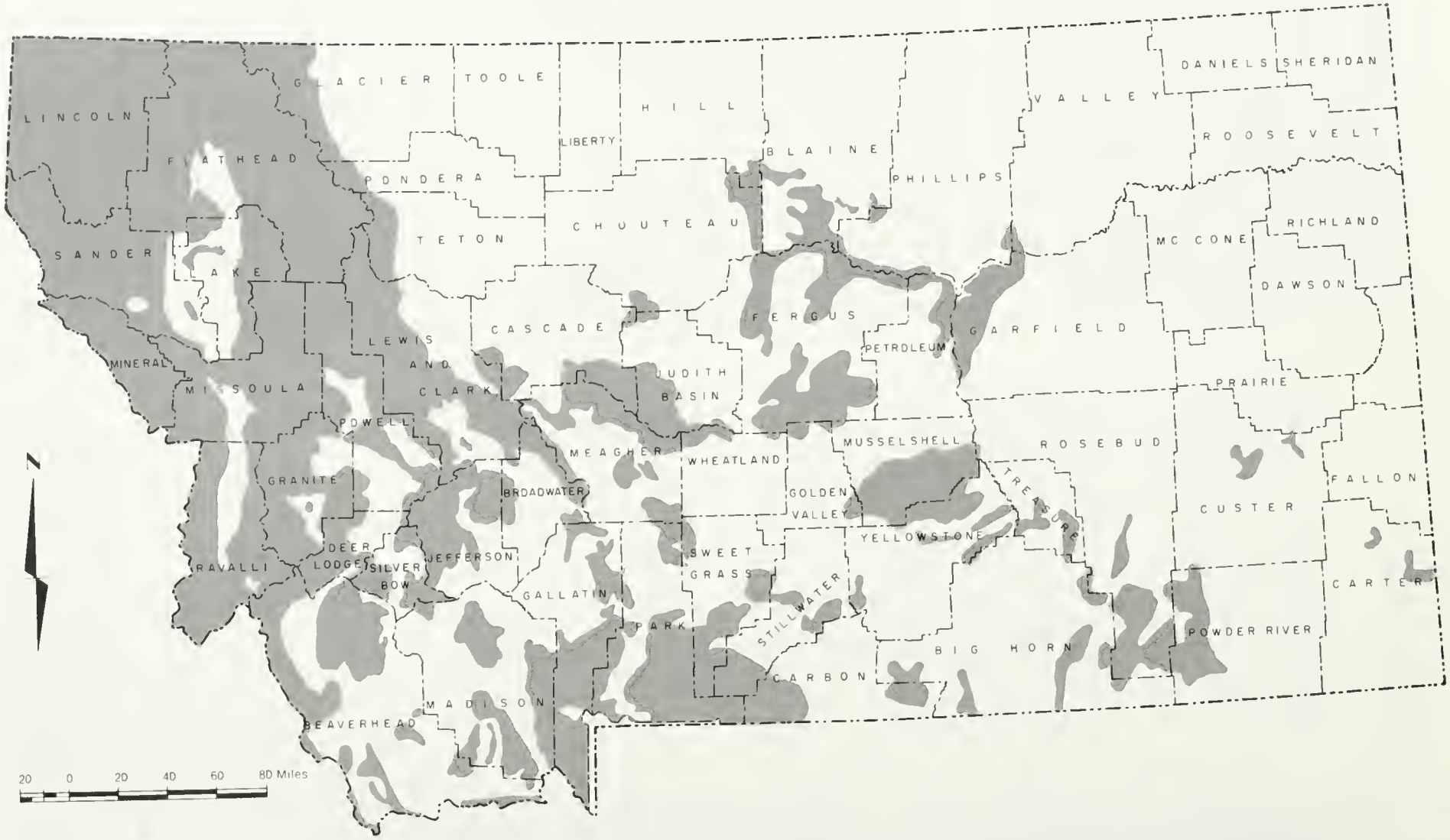
(a) Overview

Animal and human wastes can be utilized for the production of methane by anerobic decomposition. Large cattle and hog feeding operations and large municipal sewage treatment facilities are potential sources of feedstock for a large scale methane generation facility.

Biological waste or excreta has the potential of generating approximately four cubic feet of methane at atmospheric pressure per pound of (dry) waste (Martindale, 1979). According to U.S. Department of Agriculture statistics there are 152 feedlots operating in Montana. These feedlots operate with roughly 118,000 head of cattle and 145,000 hogs (Montana Department of Agriculture). If all the wastes from these animals were utilized to generate methane the could result in an additional supply of 21,804 MCF (thousand cubic feet) of methane daily. This figure is based upon a waste generation figure of 20 pounds per animal per day (Henningson, Durham and Richardson, 1976). If the yearly human excreta production in Montana is included, the potential methane production could be increased significantly. The generation of methane on a large scale might require transportation of the feedstock to a central facility. An evaluation of the quantity of this resource must, therefore, consider the geographical distribution.

Solid waste in the form of combustible trash which is generated by the citizens of Montana represents a significant potential energy source. In 1975, combustible trash material was generated at the rate of 355,426 tons per year (Henningson, Durham and Richardson, 1976). This comprised roughly 77% of the total solid waste by weight. This resource, on the basis of 4000 BTU's per pound, offers a potential energy source of 47 million barrels of oil per year. However, consideration of the geographical distribution must also be made. Much of the remaining 23% of the state's solid waste is in the form of recyclable materials which can offer additional energy savings through conservation. This aspect is considered in the Technology Profile element.

Figure 13. Existing forest areas in Montana



Agricultural crop residues and surplus on distressed grain products are also potential energy sources. Crop residues may be burned directly or utilized in a methane conversion process. Grain crops such as wheat or corn can be converted to alcohol for use as a fuel.

(b) Sub-tasks

The sub-tasks of this task are to:

(i) compile existing data on animal waste generation on a geographical basis in Montana and compile similar data for sewage treatment facilities.

(ii) develop a simple model for methane generation from biomass which will estimate future supplies with changes in population and energy source raw stocks accounted for. Spatial variations will also be described.

(iii) develop similar but separate information for municipal solid waste resources and for agricultural residues and surplus grain stocks within Montana.

(iv) prepare information for distribution to REV personnel, government agencies and the public.

(c) Methodology

Sources of information on agricultural crops, livestock, and municipal solid waste and sewage treatment facilities will be assembled and reviewed for use in the analysis. A means for continuing input to the data base will be established through the appropriate agencies. Solid waste, biomass and agricultural statistics will be obtained on a regular basis from the Montana Department of Health and Environmental Sciences and the Montana Department of Agriculture.

Table 17. Resource Assessment Element Timetable

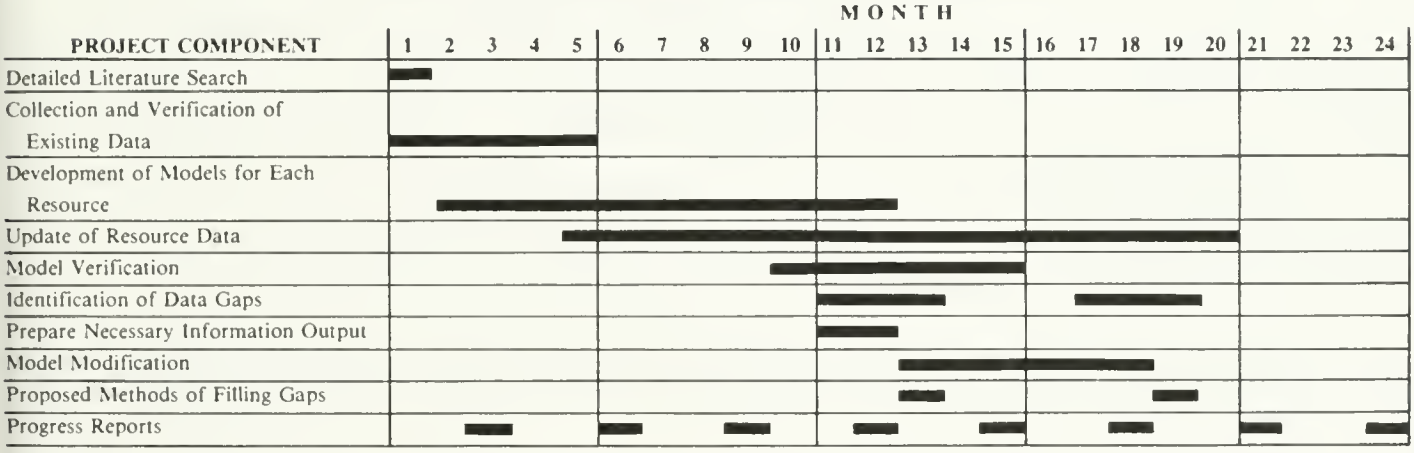

MONTH
PROJECT COMPONENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Detailed Literature Search
Collection and Verification of Existing Data
Development of Models for Each Resource
Update of Resource Data
Model Verification
Identification of Data Gaps
Prepare Necessary Information Output
Model Modification
Proposed Methods of Filling Gaps
Progress Reports

Table 18. Budget: Resource Assessment Element

	Year 1		Year 2		Total
Personnel					
Professional	1 FTE @ $20,000	$20,000	1 FTE @ $21,400	$21,400	$ 41,400
Support	1.5 FTE @ $13,000	19,500	1.5 FTE @ $13,910	20,865	40,365
Subtotal		**39,500**		**42,265**	**81,765**
Benefits (17%)		6,715		7,185	13,900
Personnel Costs		46,215		49,450	95,665
Travel		2,500		2,000	4,500
Computer		3,000		3,000	6,000
Printing		500		1,500	2,000
Other		—		—	—
Subtotal		52,215		55,950	108,165
Overhead (15%)		7,832		8,393	16,225
TOTAL COST		**$60,047**		**$64,343**	**$124,390**

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IMPACT ANALYSIS

ECONOMIC IMPACT ANALYSIS

BACKGROUND

The last several years have seen a shift in perspectives taken by individuals and government officials when evaluating energy policy. The impact of energy development, production and consumption on local economic activity and jobs is one of the most critical concerns to both the public and government officials. "Pocketbook" concerns are, therefore, critical to energy policy and may prove to be some of the most important issues affecting the eventual transition toward a society based upon fuller use of alternative energy sources.

The direction and magnitude of economic impacts will vary significantly with the geography and socio-economic "make-up" of the region under study. Existing energy supplies and prices will, through their relationship with existing industries, impact industry responsiveness to price changes. Sparsely populated rural areas may experience a relatively significant employment impact from the development of local energy supplies. A region lagging in industrial development will benefit less from backward linkages in the manufacture of parts and equipment for renewable energy technologies than will an area with much industrial infrastructure.

It is important, then, to briefly list important regional characteristics and concerns of interest to this project:

1) Montana is an area lagging in industrial development, with relatively little manufacturing and processing activity.

2) Current energy prices to Montana industrial and residential customers are among the lowest in the nation.

3) Montana is a large state with many small, rural communities served by rural electric cooperatives.

4) Some Montanans have a strong sense of independence and self-sufficiency.

5) Several large resource processing industrial plants are responsible for a significant share of the state's energy consumption.

6) The labor market is fairly localized and labor market conditions vary significantly among areas of the state.

7) The labor force is small and widely dispersed geographically.

8) A major objective of the study is to examine how local communities may be impacted by a shift toward renewable energy and conservation.

Integral to this economic impact analysis is information about the technologies considered feasible for Montana and the socioeconomic setting into which they will be introduced. Information such as this will be developed during other elements of this project. The technology profile will assemble data on the capital and operating costs of different conservation measures and renewable energy technologies and, if available, labor and occupational skill requirements. The supply/demand element will develop information on the rates at which the subject technologies will be adopted over time, their relative mix in the energy system and the dollar impacts of changing energy prices over time. Baseline economic and demographic projections will be exogoneous data to the impact model.

The purpose of the economic impact analysis is to examine and analyze the economic impact of increased use of renewable energy sources and energy conservation in Montana, including price changes which may accompany the change in energy supply mixes.

The economic impact analysis will use the basic analytical framework developed in the supply/demand element in order to provide quantitative measures of the impact of increased use of renewable systems and changes in energy price on industrial mix and output, employment, income and population. Qualitative methods will be used for assessing economic impacts which do not lend themselves to quantitative analysis, for example, economic stability over time, regional and community self sufficiency and the ability of citizens and government to influence their economic destiny.

Specific objectives are to:

1) estimate direct statewide economic impacts due to the expanded use of renewable energy and energy conservation technologies in Montana, including associated energy price changes.

2) determine secondary, or indirect, income and employment impacts through an assessment of occupational requirements and wage structures for the renewable energy supply systems and conservation measures, including the income effects of savings through conservation.

3) determine the potential magnitude of shifts in industrial output and employment due to changes in their energy input prices through personal contacts with energy intensive industries.

4) assess potential changes in the spatial distribution of economic activity due to the relatively more site specific nature of the renewable technologies when compared with conventional energy supply sources.

GENERAL METHODOLOGY

Initially, aggregate (statewide) direct impacts will be estimated. Secondary employment and income impacts will be estimated through an examination of wage structures and resulting income to the workers necessary for the construction and operation of the renewable systems and conservation measures. Labor requirements will vary with capital invested and operating expenses to the extent wage differentials exist between occupations required for the different energy supply systems. It is likely that the relationship between wages in the emerging technologies and those in conventional technologies will change over time, particularly as renewable energy industries mature and adopt technological advancements increasing labor productivity. Attention will be paid to the potential for a change in relative wages over time.

An important distinction must be made between aggregate economic impacts of different energy supply mixes and how those impacts will be spatially distributed. In addition, dispersed local technologies will generate a different spatial incidence of employment and, perhaps price impacts, than will centralized facilities.

Because of their site specific nature, it is conceivable that all of the labor required for operation and maintenance of these systems will be a net addition to the local area. However, the aggregate impact of these employment requirements may be different since labor needs in one area may simply offset those required in another area. Here, the question is, what are the **net** aggregate employment impacts of the renewable energy supply systems and conservation measures.

Occupational mixes and skill levels required for the construction and operation of renewable systems are important for examining the ability of local and regional labor markets to supply the needed labor. Difference in skill requirements between the local systems and the more centralized renewable energy technologies will also be assessed, where applicable.

Economic impacts due to changing energy prices to the consumer will also be looked at. Changing energy prices will affect consumers' disposable income, production costs for industry, and, perhaps, industry production processes.

Generally, increased energy production costs will be passed on to the consumer, depending upon the structure of the energy producing industry and degree of regulation. Other things equal, this will tend to lower consumers' disposable income and result in less expenditures on goods and services. Of course, the converse is also true; relatively lower energy prices or cost-effective conservation measures will increase discretionary income and subsequent consumer expenditures.

Montana has a large proportion of energy-intensive industries, including aluminum, copper, lead and zinc processing, oil refineries and cement manufacturers. If increased use of renewable energy technologies causes an increase in energy prices to these industries through, for example, reducing load demands on existing energy sources, there will exist the potential for production cutbacks or closure. These types of impacts could dominate all others, thus careful attention will be paid to both the potential for price increases due to reduced load demands and the impact of higher prices on these particular industrial facilities. Also, the role of energy prices on industrial location will be generally examined for opportunity costs (in terms of foregone new industrial facilities) of increasing regional energy prices, particularly since current energy prices in Montana are low by national standards.

SPECIFIC TASKS

The purpose of this component of the model is to provide a mechanism for estimating the impacts of changes in energy price, availability, and supply mix on employment, income, and population. The potential effects of various energy scenarios developed from the supply/demand element are to be assessed relative to the baseline projections. Many, if not most, of the parameters linking consumption and production patterns to economic variables will have to be subjectively determined.

Task 1

Compile state level energy use or output, data expressed in total BTU's for each economic sector of the model. The following sectors are suggested for use in the initial system:

Agriculture (including proprietors)
Lumber and wood products
Primary metals
Food products
Refining
Other manufacturing
Metal mining
Coal mining
Other mining
Oil and gas extraction
Heavy construction
Railroads
Federal government
    Total Basic
Other construction
Other transportation
Utilities
Communications
Trade
Services
Finance, insurance, real estate
State and local government
Non-farm proprietors
    Total Non-Basic

Task 2

State level employment data will be collected for each of the above sectors. Comparisons will be made over time between employment by sector and energy use or energy output data to determine the degree of historical association, if any, among these variables. Comparisons of physical output by sector (tons of ore, bushels of wheat) and energy use should also be made when possible.

These comparisons should include both average and marginal variations. Lagged relationships should also be investigated. The extent to which such initial employment, output and energy use parameters can be developed will be constrained by the energy data series developed in Task 1.

Task 3

The relationship between income and employment for each sector will be determined using regression and time series analyses. The relationship between total employment (i.e., the sum of the sectors) and population will also be investigated. Linkages between these two variables should, however, not be linear and must incorporate likely changes in female participation, average hours worked, and the demographic distribution.

Task 4

The coefficients (average or marginal) developed between employment or output and energy use by sector will be used to establish subjective bounds for simulating the impacts of changes in energy availability or price. For example, if industry A has used X BTU's per employee, the **maximum** effect of a negative change in energy availability on employment will be assumed to be:

$$\triangle \text{ Employment} = \triangle \text{ BTU's} \times \frac{\text{Employment}}{\text{BTU's}}$$

Even though the short run employment impacts could exceed this level it is likely that the long run impacts will be somewhat less, given improvements in technology. On the other hand, under high energy prices, the producer might substitute labor for energy, resulting in the creation of more jobs.

Task 5

The range of plausible energy scenarios flowing from the supply/demand model should be input into this initial framework to determine the magnitude of results. The potential employment effects of energy change should be transformed into both income and population effects to determine maximum impacts.

Task 6

Given this initial background information, energy-intensive sectors will be analyzed to more closely define how each sector would react (adjust employment and shift technology) to a price change or shortage. This subjective information is necessary to even begin to explore the magnitude of possible impacts. This section of the project should be closely coordinated with the technology element.

Task 7

Positive employment and income impacts of new technologies (construction and manufacturing) are also to be explored. Again, output necessary to simulate employment impacts will largely be developed in the technology profiles.

Task 8

Changing energy prices may result in either a loss of real buying power or an increase in disposable income. Although no state specific data are available, these potential income shifts can be analyzed using national information, specifically the Consumer Price Index survey. Econometric procedures can be adopted to model this phenomenon at the state level. A simulation system using real baseline income and total energy use in BTU's, with exogeneous price assumptions, would be developed to determine the feasible range of income changes due to changing energy costs. Since employment in non-basic sectors is largely a function of income, secondary income and employment effects could be loosely analyzed.

Task 9

Once the state level impact model has been developed, county level models could be constructed for each of the model energy communities using similar techniques. Heavy energy users in each area will be surveyed. Long range baseline projections for each area will be developed in a manner consistent with the state projections used in the supply/demand model.

Task 10

Given the subjective nature of the impact coefficients, it is suggested that monte carlo techniques be used to constrain impacts to a plausible range - to be determined by the study team.

Table 19. Budget: Economic Impact Element

	Year 1		Year 2		Total
Personnel					
Professional	1 FTE @ $20,000	$20,000	1 FTE @ $21,400	$21,400	$41,400
Benefits (17%)		3,400		3,638	7,038
Personnel Costs		23,400		25,038	48,438
Travel		500		500	1,000
Computer		750		750	1,500
Printing		150		350	500
Other		—		—	—
Subtotal		24,800		26,638	51,438
Overhead (15%)		3,720		3,996	7,716
TOTAL COST		**$28,520**		**$30,634**	**$59,154**

ENVIRONMENTAL IMPACT ANALYSIS

BACKGROUND

Since the late 1960's, concerned citizens and public officials have become increasingly aware of the adverse environmental impacts caused by conventional energy supply systems. Projected increases in energy demand, and the resulting push for new coal-fired thermal electric power plants and nuclear facilities, have met with increasing public opposition due to concerns over potential damage to public health caused by air pollution, hazardous wastes and adverse social and environmental impacts caused by the large scale mining of coal. Thus, interest in renewable energy supply systems was originally due to their supposedly benign environmental impact when compared with conventional energy technologies. Similarly, conservation is thought to have net positive environmental impacts due to its ability to reduce the projected need for conventional, centralized energy systems.

It should be clear, though, that no system for supplying energy is totally devoid of adverse environmental impacts. While renewable technologies have been vaunted as having little or no adverse environmental effect, clearly, the major burning of wood in a confined airshed, the disposal of brine from geothermal operations, and the hazard to migrating waterfowl from large horizontal axis wind generators are each examples of how this is not universally the case. An attempt will be made to identify environmental residuals or environmental hazards associated with candidate technologies the project proposes to place an emphasis on, generally determining the potential for adverse environmental impacts arising from the use of renewable energy technologies in Montana, and quantifying, where possible, the costs of these impacts and the benefits from the conservation-induced reduction in adverse environmental impacts arising from conventional energy supply systems.

Other elements of this project will provide necessary input to this element. The energy supply/demand element will develop scenarios providing measures of the rate of adoption of specific conservation measures, their effectiveness in reducing baseline energy end-use projections and the geographical incidence of their adoption. The resource assessment element will provide information on the availability of renewable energy resources which, in conjunction with the supply/demand and technology assessment elements, will assist in identifying more site-specific resource requirements (bioconversion, wood residues) impacting the local environment. The technology assessment element will provide necessary information on environmental impact coefficients of renewable energy technologies.

It is important, throughout the process of developing an environmental assessment methodology, to remain cognizant of Montana-specific conditions and concerns of interest to this project. Proper acknowledgement of these will shape the focus of research and lend the necessary perspective essential to a meaningful and relevant research design. Several of these issues are listed below:

1) Montanans are environmentally aware; they place a high priority on retaining their high quality natural environments.

2) Wildlife is one of Montana's most important physical assets; consumptive and non-consumptive uses are both valued highly.

3) About one-third of our land is owned by the Federal government. The figure is much higher in western Montana.

4) Solar energy may be proven practical. Large amounts of wood and plant residues are also available.

5) Geothermal resources have been identified. Interest has also been expressed in small scale hydropower development. Wind conditions on the eastern plains appear suitable for wind energy systems.

6) Much open space exists. Many communities are small and rural; only three cities have over 50,000 inhabitants.

It is important to recognize the inherent limitations in attempting to compare the environmental impacts produced by alternative energy systems, given that future energy growth from conventional systems may prove incompatible, over time, with maintaining the integrity of our ecosystems. Renewable energy technologies may result in less severe overall risks to public health and ecosystems, but in certain cases, such as land use, pose institutionally complex problems of a different nature. Also, the information needed for analyzing the diffuse and long term higher order consequences of ecosystem impacts unfortunately does not exist. This is particularly true when one realizes that major technological advancements in such areas as pollution control and solar and wind systems may perhaps occur, causing changes in residual coefficients and resource requirements. Therefore, this element will attempt to present a logical and consistent methodology for comparing renewable energy technologies with more conventional supply systems, allowing for both quantitative and qualitative analyses of projected environmental impacts.

As an indication of the kinds of environmental and social impacts which may be associated with various alternative energy sources, Table 20, from the California study of distributed energy systems, is included.

RESEARCH OBJECTIVES

The objective of the environmental impact analysis will be to qualitatively and quantitatively where possible, examine and analyze the regional and site specific environmental, health, and safety impacts resulting from a more widespread utilization of renewable energy technologies in Montana. Particular attention will be paid to the "prototypical" community assessments.

Specific objectives are:

1) Determine major environmental issues from a thorough understanding of the feasibility of renewable energy systems in Montana, and Montana and community specific conditions concerning land use and physical resource availability and requirements.

2) Utilizing impact coefficients produced by the technology element and scenarios developed by the energy supply/demand element, to develop regional and community specific environmental impacts.

3) Estimate the reduction in dollar costs due to human health and physical damage through conservation induced reductions in energy supplied from conventional sources.

4) Through the community assessments, explore more specifically the local trade-offs due to the adoption of decentralized energy sources vis-a-vis the centralized energy technologies.

GENERAL METHODOLOGY

Environmental impacts to be examined fall into three general categories; physical resources, human resources and ecosystems. Physical resources will include such considerations as land use, water consumption, air and water pollution, material and energy requirements for the technologies, climatic impacts and aesthetics. Human health effects will result principally from air pollution, occupational risks and accidents, and hazardous and toxic wastes. An ecosystem can be defined as the interacting biological community and physical components that occur in a given area. The ecosystem analysis will look at the composite effects on ambient biological conditions arising from the physical impacts described above.

It should be reiterated that substantial uncertainties surround any assessment of the ecological effects and human consequences of identified stresses on our environment. In addition, new technologies present many unknowns simply because we have no history of "on the

Table 20. Some Possible Environmental and Social Impacts of Alternative Energy Sources*

Active/Passive Solar Heat/Cool	Passive	Active Heat	Active Cool
construction materials—resource demand & pollutants from their production	x	xx	xx
accentuation of grid peak in poor weather	x	x	
relatively high land use to minimize shading	x	x	x
accidents/injuries in rooftop collector maintenance		x	x
leaks of working fluid—health(?) & property damage		x	x
leaks of storage medium—property damage		x	x
removal of shade trees		x	
aesthetic intrusion		x	x
water use for cooling			x

On-Site/Central Wind Systems	On-Site	Central
land use for low interference & transmission grid	x	xx
aesthetic intrusion	x	xx
accident risk - sudden blade failure	x	x
bird catching	x	x
TV interference	x	x
aircraft navigation hazard		x
microclimate effects through energy extraction & redistribution		x

Waste/Farm Biomass Systems	Waste	Fuel Farm	Electricity Farm
impacts of transportation in collection	x		
land use for collection		xx	xx
land use for transmission grid			xx
fertilizer and pesticide effects		xx	xx
irrigation water		xx	xx
particles, NO_x, CO, HC from combustion	xx	xx	xx
explosion in gasifier	x	x	
fire in fuel storage	x	x	x

Geothermal Heat/Electricity	Heat	Electricity
land use for harvesting - subsidence	xx	xx
land use for transmission grid	x	x
water consumption for cooling		xx
salts - water pollution	xx	xx
H_2S - air pollution	xx	xx
noise		x

Small/Large Hydroelectric Dams	Small	Large
significant evaporation loss of water	x	xx
loss of flowing river habitat/recreation	xx	xx
potential for catastrophic dam failure	x	xx
land use/population displacement	x	xx

Increased End-Use Efficiency	
materials substituted for energy—resource demands & pollutants from their production	x
aggravation of indoor air pollution through reduced ventilation	x
smaller cars — higher fatality rate	x
user must think more about details	x

*Two x's mean there is a reasonable probability on present evidence that the problem is serious.

SOURCE: **Distributed Energy Systems in California's Future: Interim Report, Volume II**, U.S. Department of Energy, March 1978

ground" use. The project proposes to pay special attention to identifying the more critical uncertainties and examining these in further detail to see to what extent these uncertainties can be reduced. This may be particularly relevant to Montana since the public and state government have consistently reaffirmed policies aimed at environmental projection and a "nondegradation" approach to our natural environments.

Preliminary research indicates that seven major areas of environmental impact will be stressed by this project element:

1) The degree to which new coal-fired power plants, and attendant facilities, or systems for delivering oil or natural gas, can be reduced or eliminated through conservation, and the resulting decreases in adverse environmental impacts.

2) Land use requirements for renewable energy technologies.

3) Potential for disruption of the soil nutrient cycle resulting from intensive use of wood and plant residues.

4) Aesthetic impacts of wind energy systems.

5) Stresses on local ecosystems caused by development of small scale hydropower facilities.

6) Potential air pollution problems in inversion-prone valleys from combustion of wood for space heating.

7) Disposal techniques for geothermal waste waters.

The spatial distribution of environmental impacts will differ depending upon the type of energy supply system. Renewable energy systems will result in more dispersed and diffuse impacts than conventional systems. Instead of large coal-fired facilities on the plains of eastern Montana with attendant air pollution and land disruption, we may see increased car travel and effluents from wood combustion in western Montana, and aesthetic and land use impacts from other systems relying on solar radiation. Geographic trade-offs of this nature will be fully explored.

Because of the study emphasis on community level relationships, the prototypical communities chosen for detailed analysis will be focused on for site specific environmental impacts. This may prove critical in three areas: air pollution resulting from the combustion of wood residues, land use requirements for centralized and decentralized energy systems relying on solar radiation, and resource requirements for biomass conversion.

SPECIFIC METHODOLOGY

The environmental impact element will be divided into two impact components and two geographic components. The impacts are those caused by the reduction in conventional energy supplies due to conservation and those due to the adoption of renewable technologies. Statewide and community specific impacts will be assessed separately.

The analysis performed within each component will be divided into three assessment tasks mentioned previously; physical resources, human resources and ecosystems. Again, the emphasis of the work program will, tentatively, be on the seven issues mentioned.

The overall impact assessment will be divided into three phases. Phase I will occur during the latter part of Year I of the project and will focus on projected aggregate impacts. Phase II will be community specific and will coincide with the community assessments. Phase III will incorporate the community findings to refine, where necessary, the information developed in Phase I. Here quantitative estimates will be made of the costs of potential environmental damage.

PHASE I

Task 1

Researchers will establish a final list of major environmental issues through analyzing information developed in the technology element and supply/demand element. This will be used to add to, or subtract from, the initial list developed above. This work will begin after initial work is completed in the other two elements.

PHYSICAL AND HUMAN RESOURCES

Task 2

The project will draw upon the impact coefficients developed in the technology profile and the energy use scenarios projected in the supply/demand element, refine estimates of aggregate physical and human resource impacts.

Task 3

The project will develop a matrix of conventional and renewable energy technologies and their respective residuals and impacts under assumptions regarding pollution control, production technologies and regulatory setting.

Task 4

This task will integrate this information into the economic/energy/environment model referred to in the supply/demand element and refine the model as appropriate.

ECOSYSTEMS

Task 5

This task will provide baseline data and adequate background information describing existing biological and environmental factors.

Task 6

This task will describe, from the impact coefficients, energy supply scenarios and resource impacts, inputs to the immediate environment. Particular attention will be paid to aquatic systems, wildlife habitat and agricultural and forest lands.

Task 7

This task will describe the nature of the stress on the ecosystem through analyses of reduced resource availability, altered chemical concentrations, altered temperatures and hydrology.

PHASE II

Task 8

This task will develop estimates of site specific environmental impacts for the model energy communities under study. Impacts to be studied will consist of both those occuring within the community and those associated with the use of the renewable technologies, but taking place outside the community.

Task 9

This task will identify impacts which may pose potential constraints to the use of renewables and, where appropriate, will refine and redesign the technology applications. If necessary, it will modify the energy supply and mix projections.

Task 10

This task will modify the matrix developed in Task 3 through incorporating information generated during the community specific studies.

PHYSICAL AND HUMAN RESOURCES

Task 11

This task will assess, where necessary, the second order consequences of direct water and air impacts through analyzing and refining existing air and water models.

Task 12

This task will review literature and existing research to determine potential effects on human health. Interface with the human population will be explored through assessment of current pollution transport modeling procedures. It will determine the potential for human health effects from occupational risks and hazardous wastes.

ECOSYSTEMS

Task 13

This task will describe the response of the ecosystem in such terms, for example, as change in net primary production, direct damage to crops and property, changes in a real extent of ecosystem type, changes in diversity, and qualitative assessments of habitat alteration.

Task 14

This task will thoroughly review existing literature on the relationship between ecosystem degradation and human welfare for its applicability to this project and will estimate the human losses due to the above ecological responses in such areas as dollar value of damage to crops and property, loss of recreational opportunities, expected deaths and cases of disease. An example might be air pollution in inversion-prone valleys from combustion of wood for space heating.

This example is included to demonstrate both the need for environmental concern, the methodological approach, and the environmental setting.

At least one of the above mentioned problems, potential air pollution problems in inversion prone valleys from combustion of wood for space heating, already exists. Missoula County is a non-attainment air quality region for particulates. Frequent winter inversions in a relatively narrow, windless mountain valley have exacerbated a situation in which urban growth and industrial emissions have combined to create a long standing air pollution problem. After ten years of public pressure, industrial emissions have been lowered drastically and now account for only 25% of the emission inventory of the valley. However, the air pollution problem hasn't gone away. As an area completely surrounded by National forests, and as the center of the wood products industry for Western Montana, it has been natural for Missoula residents to turn to wood heat as a cheap alternative to fossil fuels for home heating. Only one low budget study has been attempted relating the use of firewood to Missoula's air pollution problem. It claims that about 20% of 1978 particulate and 40% of 1983 particulate (winter season) comes or will come from fireplaces.

METHODOLOGY

1) Use Survey - The use survey carried out by Ottis in 1978 for Missoula County was flawed in that the sample size was too small for adequate analysis. Also, that survey did not adequately define the types of stoves used by Missoula residents, nor did it define the mix of types of wood burned. Finally, the current trend toward the burning of firewood and the types of stoves are crucial factors in the analysis of impacts of both air quality and forest ecosystems and the follow-up study would be necessary even if the first study were adequate.

Such a "use survey" coupled with emission inventory analysis can lead to a quantification of the amount of wood caused particulates in the valley.

2) Monitoring - Missoula County has one of the most sophisticated particulate monitoring systems in the country. This is because the city has been one of the focal points of a state effort to determine the effect of air pollution on human health. With very little added expense, the filter systems on two devices which measure particle sizes can be used to determine the proportion of "wood smoke" in particulates. The simplest technique will be to analyze filters for total carbon. Such a study is necessary to check the "use survey" approach quantification of the wood induced air pollution problem.

3) Health Effects - Separate from the "non-attainment" status question is whether wood smoke is actually harmful to human health. It is hoped that the current "Montana Air Pollution Study" will provide some information on this question. If it does not, there are two relatively inexpensive tests which can be carried out:

a) Ames tests for mutagenicity on selected particulate samples (large and respirable particulates; summer and winter samples).

b) Gas chromatographic analysis for polyaromatic hydrocarbons from the same sample as in (a).

Table 21. Budget: Environmental Impact Element

	Year 1		Year 2		Total
Personnel					
Professional	.6 FTE @ $20,000	$12,000	.7 FTE @ $21,400	$14,980	$26,980
Benefits (17%)		2,040		2,547	4,587
Personnel Costs		14,040		17,527	31,567
Travel		500		500	1,000
Computer		—		—	—
Printing		150		350	500
Other		—		—	—
Subtotal		14,690		18,377	33,067
Overhead (15%)		2,204		2,756	4,960
TOTAL COST		**$16,894**		**$21,133**	**$38,027**

SOCIAL IMPACTS ANALYSIS

THE IMPORTANCE OF SOCIAL DIMENSIONS

Most would agree that the ability to utilize renewable energy sources offers advantages over continued dependence on depletable energy sources, all things being generally equal. As society intensely pursues solutions to the technological and economic problems of renewable sources, more attention should be addressed to the related social dimensions of possible adoption of renewable technologies. The associated social impacts, barriers and incentives demand insight and attention commensurate with the analytical problems they present.

Until recently, it has been common practice in procedures such as technology assessment and environmental impact assessment to consider social impacts as a residual. In some instances they have been perceived as little more than troublesome "side effects" which nonetheless are required to be considered. It must be realized, however, that even the "primary" environmental or economic impacts are ultimately social concerns. For example, how much pollution to accept and the cost of achieving cleanup are collective decisions resting on social values and realized through institutions, primarily government.

The social dimensions of renewable energy technology are not easy to isolate for analysis because they enter the problems in a number of complex, interactive ways. One approach is for the analyst to work backward from identifying the social impacts of adopting a renewable energy technology. Those impacts that are positive can be identified as facilitators or accelerators of transition. Those impacts that are negative can be viewed as barriers to the implementation of the technology.

It is inappropriate to think that solving technological problems must precede solving economic problems which in turn must precede social impact problems. It may be the case that a particular technology will be unacceptable to people no matter how "proven" or "economical." Insight into such social resistance should be developed concurrently with the technical assessment. Social impacts must be considered more than simply residuals, for it is social receptivity which will condition the degree of emphasis placed on a policy of fostering renewable energy.

CONCEPTUALIZATION OF SOCIAL IMPACTS

Social impacts include changes in behavior, attitudes, values, lifestyles, and beliefs. They may affect work, recreation, or a number of other behavioral modes. A commonly unexamined premise of renewable energy technologies is that they are inherently benign and that it is only their primitive state of technological development and consequent high cost which has prevented their full embrace by people. In fact, it is assumed that once economic marginality is neared, these social benefits will be sufficient to induce adoption and diffusion of the technology. These social benefits include features such as decentralization of decision-making, more direct individual participation and enhancement of a sense of involvement, more comprehensible technology, reduction of labor alienation, greater consumer choice, higher local economic multipliers, the development of a broader range of individual skills and the creation of a greater sense of community among neighbors.

In nearly each case the alleged benefits are highly subjective, open to question, and perhaps, highly personal. And, in each case, there may be a corollary disbenefit such as increased labor demands, inconvenience, lowered reliability or the alteration of old habits.

Adoption of renewable energy will affect individuals, not as individuals per se, but as individuals in various roles which are played intermittently. A person may be affected as a producer, worker, businessman, consumer, traveller, recreationalist or other. What motivates a change in individual behavior in one capacity may have little effect in another. Receptivity to a new technology may depend upon the context of its effect in various roles. In some cases, people will continue to pursue certain luxuries even at very high energy costs.

It is inappropriate to treat the social impact of renewable energy technology as an aggregate. The various technologies are uneven in their expected application. Consequently, the degree of social impact will vary widely.

SPECIFIC METHODOLOGY

Task 1. Literature Search

Prior to the final selection of the appropriate methods for predicting and analyzing potential social impacts, an exhaustive inventory of potential positive and negative impacts must be drawn from a search of the literature.

Task 2. Attiudinal Survey

The point of departure for predicting the potential social impacts is a survey of Montanans regarding their perceptions of renewable energy and their own projections of changes in their attitudes and behavior. This task will be carried out jointly as a part of the public input and participation element.

Task 3. An Examination of Social Impact as Causal Factor

Social impacts are not just something that happens after a decision is made. Social factors play a vital role in influencing decisions which are made — both public and private. In this section, social factors as causal factors will be examined both in general, and also by specific technology. The principal social scientist on the research team will work closely with the supply/demand team in providing quantitative and qualitative input into the supply/demand simulation analysis.

This task will also require working closely with the transition analysis team at both the state and local levels. The issues of social impacts and transition are tied together through the matrix of institutional decision-making. "social" thus is the generic category for legal, educational, governmental, associational and other issues dealing with shifts to renewable energy and conservation. The current legal/government framework stands both as a set of institutional impediments to the transition and as the mechanism through which negative impacts can, in part, be ameliorated. Examinations of the role of federal, state, local and other governments in both of these capacities will be necessary. Governmental decisions which affect both producer and consumer as well as intermediate energy delivery roles will need to be addressed. This will be a two-part process. The first will be the development of a compendium of current pertinent laws which either favor existing uses of nonrenewable energy or penalize adoption of renewable sources. This will be more perfunctory than creative. The second part will be the identification of policy initiatives which could reverse the existing pattern together with an analysis of the side consequences. This task will be more demanding and challenging.

Institutional constraints which need to be addressed include investment and loan mechanisms, subsidies and tax credits, zoning and planning law, territorial integrity provisions, marginal pricing mechanisms, life cycle cost investment incentives and peak load electricity rates.

One matrix for addressing the transition conceives of three types of behavioral modification:

1) **Regulatory** in the form of prescribed behavior, as in gasoline rationing and negative sanctions, such as fines for violating the speed laws;

2) **Positive incentives** such as insulation tax credits; and

3) **Education**, the identification and reinforcement of self-interest.

Task 4. An Examination of Social Impacts as Dependent Variables

Some degree of trauma or adjustment is inevitable whenever a society is forced dramatically to modify one of its basic modes. As discussed above, resultant social impacts can include changes in behavior, attitudes, lifestyles and beliefs. Such impacts associated with broad changes as well as specific candidate technologies will be examined here.

Task 5. Consultative Input to Information Dissemination

The insights and understanding gathered through the research in this task will be of material utility to the information dissemination team. Expressed informational needs and analytically identified gaps in public understanding will both be important input to the operation of a successful information dissemination element.

Table 22. Budget: Social Impact Element

	Year 1		Year 2		Total
Personnel					
Professional	.5 FTE @ $20,000	$10,000	.5 FTE @ $21,400	$10,700	$20,700
Benefits (17%)		1,700		1,819	3,519
Personnel Costs		11,700		12,519	24,219
Travel		500		500	1,000
Computer		250		250	500
Printing		150		350	500
Other		—		—	—
Subtotal		12,600		13,619	26,219
Overhead (15%)		1,890		2,043	3,933
TOTAL COST		**$14,490**		**$15,662**	**$30,152**

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TRANSITION ANALYSIS

It is the expressed policy of the State of Montana to make a transition to an energy future using more renewable sources of energy and energy conservation. The transition analysis element in REV deals with exploring how Montana might move toward energy conservation and renewable energy sources. The transition analysis is the central integrative element of the project, and is built upon the foundation of technical, resource, economic, and impact information. It is an analytical and organizational process where problems are identified and potential solutions are analyzed in a real world setting.

Energy decisions are influenced by many economic, political, institutional, and social forces. The human dimensions of the energy picture frame today's energy policy setting. The importance of the transition analysis lies in its emphasis on the human and site specific elements through a major local component. This element concludes with a state level analysis and synthesis. Project relationships are depicted in Figure 14.

THE POLICY SETTING

The services energy performs are extremely important elements of the modern economy and quality of life. Without energy the national industrial machine and transportation system would grind to a halt. As an ingredient in virtually all goods and services, the costs of energy significantly influence general price levels. Energy contributes to all of the following: economic growth and stability; the cost of living; the distribution of the world's wealth; environmental pollution; human health; and the general quality of human life. But, while all agree that energy is important, there is a great and continuing national debate on what should be done. In that debate, the conventional wisdom is being challenged in the areas of energy consumption and centralized high technology solutions.

ENERGY CONSUMPTION

Denis Hayes (1977) states that an investment in energy conservation will save more energy than a similar expenditure on new energy facilities will produce. Hayes and others argue that energy use and economic activity are not linearly locked together, where a decline in energy use would necessitate a drop in production (Hayes, 1977; Lovins, 1977). A further dimension of the energy consumption issue is the relationship between energy conservation and jobs. Recent studies indicate that there may actually be greater positive contributions to employment through transitional fossil technologies and conservation than through conventional centralized energy production (Grossman and Daneker, 1977). In a recent evaluation of the job creation potential of solar and conservation, economist Meg Schachter stated:

> *"In sum, while the employment effects of alternative energy systems have not yet been determined with accuracy, preliminary analysis indicates that an energy strategy designed to promote the development of these industries would have a favorable effect on direct job creation." (Schachter, 1978).*

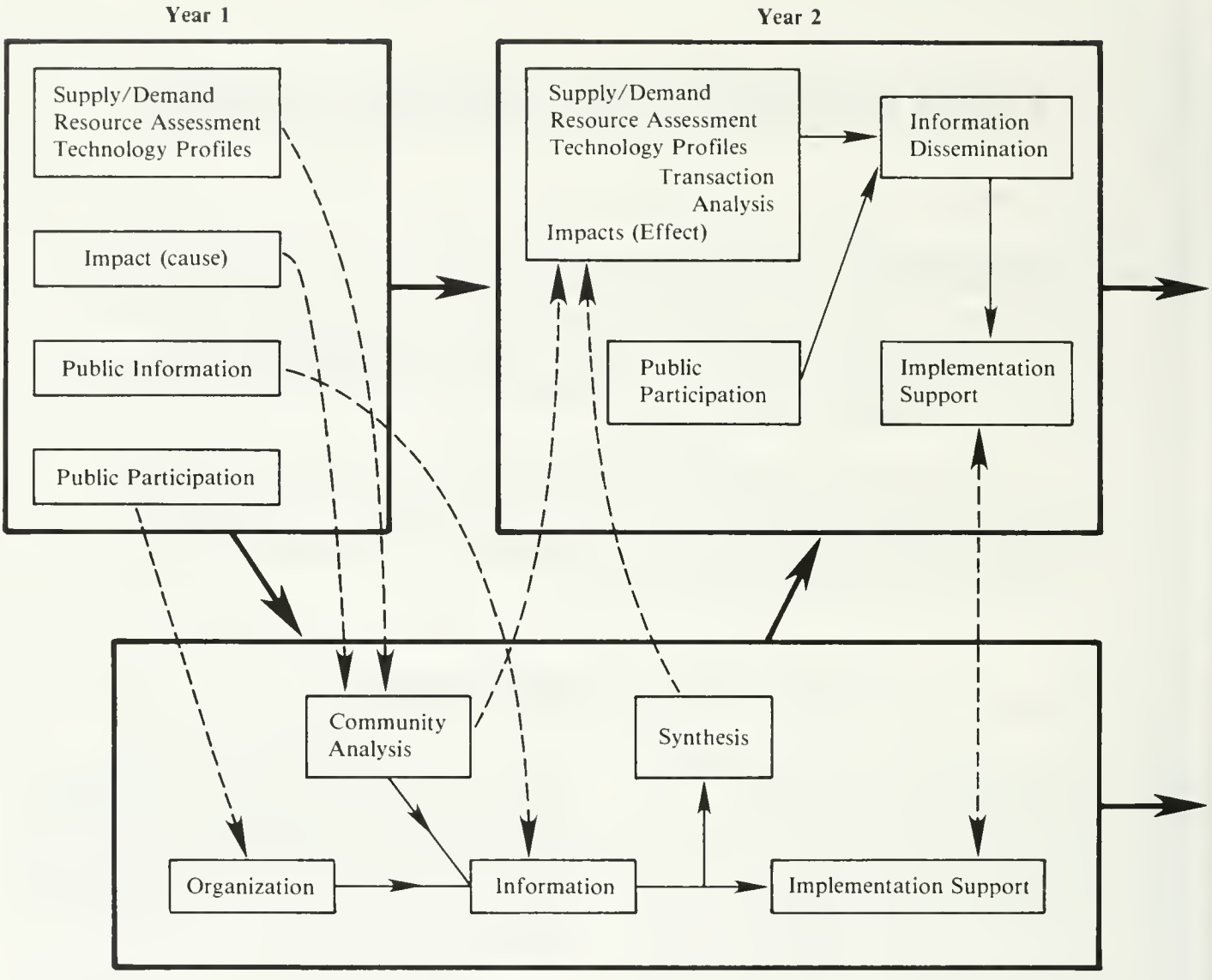
In a recent study for the Economic Council of Canada, economist, David Brooks examined the economic impact of low energy growth in Canada (1978). His conclusions:

> *"A survey of other research indicates that opportunities to increase energy efficiency are numerous and, in the main, conducive to increased enlployment, reduced capital demand and lower inflationary pressures."*

Brooks also found,

> *"It is concluded that a low energy future is not only consistent with sustained improvements in the standard of living, but also with Canadian self-reliance in energy." (Brooks, 1978).*

Figure 14. Schematic diagram of project relationships in state and local transition analysis



CENTRALIZED LARGE-SCALE HIGH TECHNOLOGY SOLUTIONS

The traditional argument for ever larger power plants is being challenged. In a document more philosophical than techincal, British economist E. F. Schumacher opened the discussion of scale with **Small is Beautiful: Economics as if People Mattered** (1978). Schumacher looked at economic scale as it relates to humanity and concluded that bigger is not always better when people are considered.

Smaller decentralized plants can be built faster, can utilize an existing transmission system with less new investment and less wheeling losses, and allow investment to be made as needed, rather than over-investing because of the quantum of the unit. A recent report by the Los Alamos Scientific Labs looked at small power plants and concluded,

> *". . . the construction of several 500-MW' power plants rather than one 3000-MW' plant would lead to a lower price of electricity to consumers in Los Angeles, fewer planning and financing problems for the electric utilities, and reduced environmental impacts in southeastern Utah." (Ford, 1979).*

Recent private decisions in strip mines in Montana have taken a similar approach, utilizing several trucks and power shovels for overburden stripping rather than one very large and expensive dragline.

Balance requires pointing out that the traditional arguments for economies of scale are widely supported.

THE CONSERVATION/RENEWABLE ALTERNATIVE

In the midst of the debate are voices arguing for an alternative. Conserve energy, they say, and use the earth's birthright of fossil fuels to bridge to a future relying on renewable energy sources. This is the theme of Amory Lovins (1977), Denis Hayes (1977), the Solar Lobby (1979), and others.

Conservation and renewable energy are certainly not new to the energy scene. Typically, however, they have been heavily discounted as near term options. Montana's policy has been noted.

President Carter's position was expressed in the National Energy Plan (1977).

"Conservation and fuel efficiency are the cornerstone of the proposed National Energy Plan" (NEP, p. 75)

"America's hope for energy to sustain economic growth beyond the year 2000 rests in large measure on the development of renewable and essentially inexhaustible sources of energy." (NEP, p. 75)

In a major statement on solar policy on June 20, 1979, President Carter stated:

"There is no longer any question that solar energy is both feasible and also cost-effective."

"By the end of this century, I want our Nation to derive 20 percent of all energy we use from the sun — direct solar energy in radiation and also renewable forms of energy derived more indirectly from the sun."

The transition analysis element contains two major components: local and state.

LOCAL TRANSITION ANALYSIS

Four model energy communities will be selected from among the cities, towns, and counties of Montana. The model energy communities will be study areas for energy use by all sectors. They will be pilot sites for the application of resource, technological and economic information and analysis developed in the statewide effort. The ultimate energy supply objective is to provide the services energy offers. The study of energy use and supply/demand options at the community level: 1) provide information to calibrate and validate statewide efforts, and 2) develop information at a geographical and political level that would facilitate action.

Many very important energy decisions are made or directly influenced at the local governmental level. While not all local jurisdictions in Montana exercise the following powers, at least some do.

- **Land Use:** Local governments may determine housing density, location of homes, places of work, shopping, and recreation, approval of major subdivisions, including PUD's; lot size, building set-back, and height restrictions.
- **Transportation:** They may decide road and street configuration, bikeways, sidewalks, pedestrian walkways and crossings, public transit (bus, dial-a-ride); street standards (width), and parking requirements.
- **Building Codes:** Cities enforce the state codes, employing building officials and building inspectors; Counties have the option to do so.
- **Public Information:** Public libraries are typically supported by taxes levied by local governments and run by a Board of Trustees appointed by local governing bodies.
- **Direct Governmental Energy Use:** Other local government functions may include ownership, operation, and maintenance of public buildings and facilities (city hall, County courthouse, shop, heated swimming pool), vehicle fleet, water supply, and sewage treatment, street lighting, tree planting programs, and parks.

Task LTA 1. Select Model Energy Communities

Four communities will be competitively selected as a model energy city, model energy town, and model energy county.

The model energy communities will serve as energy data gathering points for the qualitative end-use profile, and will receive concentrated technical assistance from the project team in the development of specific information and proposals tailored to that study area. Because many of the renewable technologies and conservation opportunities lend themselves to application on a small, decentralized scale, the model energy community provides a practical way to explore energy opportunities in a general sense, while at the same time providing specific technical assistance where action might result.

Criteria: The model energy city must be a class A city (defined under Montana law); the model energy town must be a city or an incorporated town smaller than class A; and the model energy county may be any county in Montana. Counties which have merged with cities fall under the classification of their largest city.

The program will be widely advertised to all potential participants. Interested communities must apply to be considered. The application should include a written statement signed by the chief local official committing local support to the project, and also should describe what, if anything, the community has done in the energy area, as well as

describing particular points of interest, such as home rule powers, potential waste heat utilization from a local industrial plant, availability of wood or animal waste, and already established citizen energy groups.

Communities will be selected on the basis of community interest and support, geographic balance, and general promise of success.

Task LTA 2. Community Organization

Community organization encompasses the broad function of dealing directly with the community, providing guidance to volunteers and community staff in information gathering and analysis.

subtask 1. hire and train local project coordinators. A full-time local project coordinator will be employed by the department on contract for months 7 through 24. Following a training period, the local coordinator will reside in the model energy community throughout the project.

subtask 2. form a local advisory committee. The purpose is to keep local residents informed, to improve the understanding of local circumstances, and to generate public awareness and participation in the project.

The local coordinator will work closely with local leaders from the beginning. The coordinator will meet with the governing body. It is helpful to get the governing body to appoint a staff member as an official point of contact. The coordinator should work closely with local officials to determine local perceptions of what the problems are and what they would like to do.

subtask 3. identify and work with special local subgroups. Depending on the community, this could include builders, bankers, architects, appraisers, realtors, building officials, planners, low income groups, and others.

Most communities have formal and informal institutions which have envolved through their history. It is important to understand the institutions in the community: what they do, why they exist. There are great pay-offs in community acceptance, economy, and continuity, and in building upon and strengthening these institutions in carrying out the energy program. The following are some examples of important local institutions:

- The library
- The planning board
- A citizens' advisory structure
- Low income organizations...HRDC's, senior citizens, native americans
- County extension agent
- Local service, environmental, business, and agricultural organizations

Task LTA 3. Community Analysis

Under the broad heading of community analysis, energy and economic data are gathered; resource, technology, and impact information are provided by the state REV team; and all flow into an analytical process where the supply/demand analysis results in the formulation of local energy scenarios of conservation and renewable forms of energy. The technical information is then examined through a barriers and incentives analysis identifying necessary and sufficient educational, market, and regulatory conditions to obtain scenario levels. After a final impact evaluation, the community analysis is complete.

subtask LTA 3-1. community energy profile. An understanding of community energy use is fundamental to the analysis of possible energy futures. The community energy profile parallels and contributes to the energy overview and qualitative end-use profile at the state level (Supply/Demand Task 2). It is, simply, a collection of historical energy statistics for the community: quantity, type, use.

The methodology retains some flexibility and will be pursued in a recursive fashion. Flexibility is necessary, as the performance of the state supply/demand analysis will both assist and place demands on the local data effort. The local energy profile will be repeated and refined as analytical needs dictate and as time, resources, and data permit.

The goal is to assemble a profile of annual use data for ten years. Use will be the sector of use (residential, commercial, industrial, transportation, government/institutional) and by qualitative end-use (heat for various temperature gradients, electrical, mechanical, light, and transportable liquids).

The general community approach will draw heavily on the Benson methodology (1979), as well as the Franklin County experience (The Franklin County Energy Conservation Task Force, undated), Hittman and Associates (1978), and Sizemore and Associates (1978). The Benson approach is currently being pilot tested in Montana through the Alternative Energy Resources Organization's Local Energy Organizers' project using CETA personnel. Another useful reference is "Planning for Energy Self-Reliance, 1979).

subtask LTA 3-2. community economic profile. Energy is an economic issue. The community economic profile is intended to parallel the community energy profile, assembling a set of historical economic statistics to describe the economic, demographic, and land use patterns for the past ten years. In the ideal situation (data permitting), the following characteristics will be assembled:

Population
Income
Employment
Trade - wholesale - no. of firms, square footage, sales
retail - no. of firms, square footage, sales
Housing - stock, building permits

Utility hookups - gas, electric, phone, water, sewer
Rural septic tank / sewer / well permits
Land use overview
Vehicle registrations
Transportation - miles of improved roads
vehicle miles traveled by type
Lending institutions and capital availability
Local governmental financial information - budget, bonding capacity
Population and employment projections - 1981, 1985, 1990, 1995, 2000.

The starting point will be the County Profiles Series prepared by the Montana Department of Community Affairs. **Economic Analysis for Local Government** (National League of Cities, 1978) and *The Community Economic Base Study* (Tiebout, 1962) are useful references. The data base will be defined by the availability of data and the perspectives of local leaders and planners.

subtask LTA 3-3. community resource assessment. Information from the statewide resource assessment element will be provided to the community analysis to serve as the first iteration of the community resource assessment. Utilizing technical input and direction from the state resource assessment team, a resource assessment report will be prepared for the community.

subtask LTA 3-4. technology profiles. The technology profiles prepared for the statewide project will be of sufficient detail to satisfy the major needs of the community analysis. This task is primarily one of transferring this information for local use.

subtask LTA 3-5. impacts (as causal variables). Economic, social, and environmental impacts are not just the effects of independent actions. Perceived impacts influence the patterns of energy development. Drawing on the results from the statewide impact element, as well as from specific technologies which match the energy use and resource availability characteristics of the community, impacts having a potentially causal relationship to the energy future will be identified and discussed for candidate technologies.

subtask LTA 3-6. supply/demand analysis.

Activity 1 researchers will forecast conventional energy prices

Activity 2 researchers will perform comparative microeconomic studies of conservation and renewable alternatives

subtask LTA 3-7. formulate community energy scenarios. Drawing on the preceding community analysis subtasks, community energy scenarios will be formulated paralleling the discussion in the supply/demand element.

subtask LTA 3-8. community barriers and incentives analysis. Human history and consumer market behavior demonstrate that there are times when an action is technically possible, but does not occur because of barriers such as lack of public understanding and acceptance, lack of cost competitiveness due to subsidized competitors, or other reasons. The purpose of this subtask is to examine the scenarios and candidate technologies from the standpoint of: 1) identification of barriers to its being developed, and 2) possible incentives that would be necessary and sufficient for the technology to be implemented.

The major categories of barriers and incentives are:

- Educational
- Market
- Regulatory

The growing literature in the area will be drawn upon. Pertinent referenees include: "Energy Planning in a Conserver Society: The Future's Not What it Used to Be" (Crow et al., 1978); "Energy Planning in a Conserver Society: Implementation of Solar Energy" (Marilyn Duffey-Armstrong and Joe E. Armstrong, 1979, forthcoming); "Legal Barriers to Solar Heating and Cooling Buildings" (DOE, 1978); "Building Codes as Barriers to Solar Heating and Cooling of Buildings" (Meeker, 1978).

subtaks LTA 3-9. impacts (effect). Following the articulation of scenarios and the examination of barriers and incentives pertaining to scenarios and candidate technologies, the impacts must be assessed in an aggregated fashion for the community. This embodies the full impact assessment, including economic, social, and environmental impacts. The assessment will not be of sufficient depth or in the separate format to constitute a formal environmental impact statement. It will, however, be sufficient to serve the purpose of a preliminary environmental review, which identifies potentially significant environmental effects, should a public action be proposed.

Task LTA 4. Community Information

This task is discussed in the Information Dissemination Element.

Task LTA 5. Implementation Support

This task will be performed if the community selects a preferred path and wants to go ahead in that direction, and will provide technical support for the initial phase within the project period.

Task LTA 6. Synthesis

Prepare a synthesis of the findings in the four model energy communities, for application to other communities.

STATE TRANSITION ANALYSIS

Montana energy policies and programs are discussed in the introduction, and are exhaustively covered in the **1978 Montana Energy Almanac** (Kuntz, 1979).

Task STA 1. Form a state governmental Renewable Energy Viability sound board.

A sounding board for general awareness of project performance and for discussion of possible policy/program recommendations will be established. The renewable energy/energy conservation sound board will consist of representatives of: DNRC, Public Service Commission, Environmental Quality Council, State Department of Health and Environmental Sciences, Commissioner of Labor, Commissioner of Higher Education, the Governor, and the Legislature.

a. The project will keep them informed from the beginning regarding the project, including activities and findings.

b. The project will involve them in the identification and discussion of barriers and incentives.

Task STA 2. Formulate State Scenarios

State level scenarios from the supply/demand element will be utilized. Scenarios will be described in terms of their renewable and conservation components.

Task STA 3. Barriers and Incentives

Identify and discuss various barriers and incentives both necessary and sufficient to implement scenario levels or to emplace candidate technologies.

subtask STA 3-1. institutional barriers and incentives.

subtask STA 3-2. economic, social, and environmental barriers and incentives.

Task STA 4. Formulate possible strategies for barriers and incentives

This task will provide scenarios involving more renewables and conservation than the business as usual scenarios, and will develop possible strategies for removing barriers or providing incentives.

Task STA 5. Impact Mitigation Strategies

This task will identify negative impacts of the facilitating strategies and discuss how they can be mitigated.

Task STA 6. Energy Decision Mapping

Everyone is affected by energy, and, in many respects, energy decisions of one sort or another are made by us all; however, energy decisions are not evenly distributed among those of us who use energy.

The purpose of this element is to examine energy decision-making in Montana: who, how, why. It could be characterized as a socio-economic-political mapping of energy consumption and production decisions in Montana.

Table 23. Transition Analysis Element Timetable

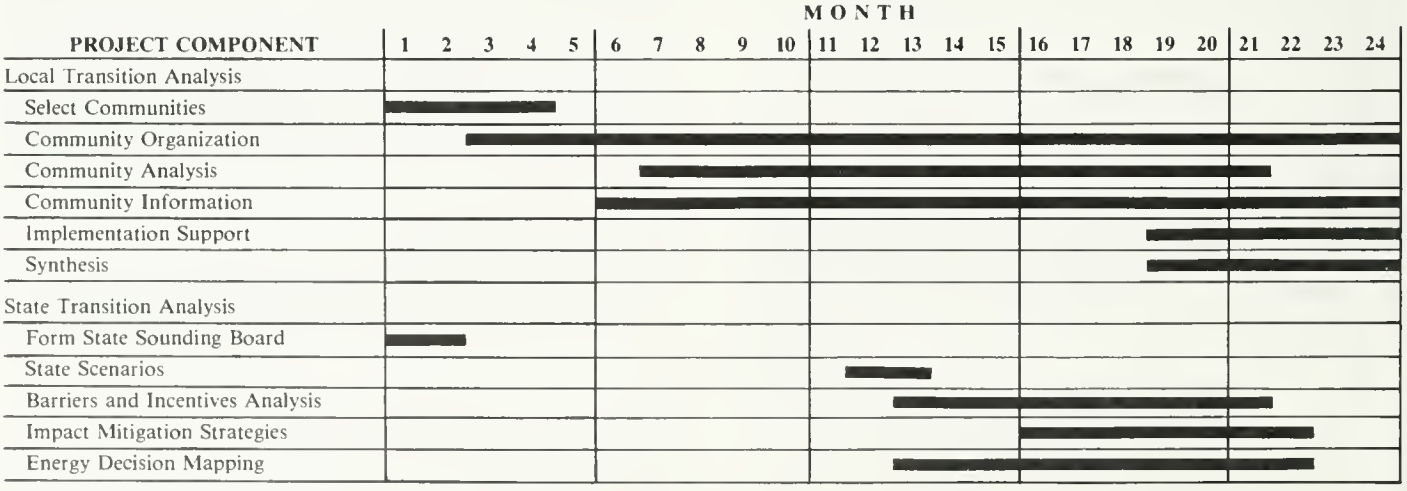


Table 24. Budget: Transition Analysis Element

	Year 1		Year 2		Total
Personnel					
Professional	.25 FTE @ $20,000	$ 5,000	.25 FTE @ $21,400	$10,700	$ 15,700
Local Coordinators	1.5 FTE @ $15,000	22,500	3 FTE @ $16,050	48,150	70,650
Subtotal		**27,500**		**58,850**	**86,350**
Benefits (17%)		4,675		10,005	14,680
Personnel Costs		32,175		68,855	101,030
Travel					
2 out-of-state @ $500.00 in-state @ $5,000		2,500		3,500	6,000
Computer		—		—	—
Printing		250		750	1,000
Other		—		—	—
Subtotal		34,925		73,105	108,030
Overhead (15%)		5,239		10,965	16,204
TOTAL COST		**$40,164**		**$84,070**	**$124,234**

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PUBLIC INPUT AND PARTICIPATION

This element of the project deals with some of the relationships between the project and the general public. For this purpose, the public is defined as all the residents of the state of Montana other than project staff and contractors. This project will attempt to approach that public both as individuals and through existing representative organizations.

THE PUBLIC AS ADVISORS

The objective of this facet of the project is to obtain public input to certain decisions concerning the design, management, and conduct of the project. The aspects of the project for which this input is desired include: choosing the specific topics (resources, technologies, impacts) to focus the research efforts; developing definitions of key concepts such as the criteria to be used in evaluating technologies; choosing the assumptions upon which to base any projections or scenarios about the future; and selecting the model energy communities. While most of these decisions will be made at the state level, there will be parallel choices to be made at the community level as well.

The rationale for seeking public input to the project is that it will enhance the relevance, understandibility, and acceptability of the information which the project produces. Such input will also help to assure that the project is responsive to the needs of the broad spectrum of Montana residents for useful information about renewable energy and energy conservation opportunities. Public input will also provide to the project a broader perspective than would be available if only project staff and contractors were involved. Finally, an opportunity will be provided for people who may be affected by decisions made using project-generated information to influence the process of collecting and analyzing that information.

THE PUBLIC AS PARTICIPANTS

The objective of this aspect of the project is to increase the project's impact in the model energy communities by involving local residents in project activities. Using community residents as volunteers will enable the project to both expand the scope of its activities and to encourage a higher level of community interest in renewable energy and energy conservation opportunities. Examples of the types of activities in which community residents will participate include: conducting neighborhood and block-specific resource assessments for solar and wind resources; surveying local residents and businesses to determine current energy use patterns; serving in a liaison capacity to particular local audiences (e.g., bankers or architects); and assisting with public educational activities through speaking engagements. The opportunities for this type of participation are more fully described in the transition analysis section of this study.

TASKS

The implementation of this element of the project involves a series of tasks with three principal desired results: to create opportunities for public input and participation; to publicize those opportunities; and to obtain the participation.

TASK 1: REVIEW WORK PLAN AND ASSIGN IMPLEMENTATION RESPONSIBILITY

When the project is funded and work is about to begin, this work plan should be reviewed and modified or updated as necessary. It is quite possible that new needs, information, and participation mechanisms may have developed since this description was written. The work plan should be changed accordingly. Equally important, the responsibility for obtaining public participation should be specifically assigned to one project staff person. At their easiest, public input and participation are difficult to obtain. Therefore, the staff person must be: committed to the concepts of public input and participation, experienced in the techniques outlined in subsequent tasks, and provided with the time and other resources needed to effectively carry out these responsibilities.

Tasks 2-7 described below relate principally to the need for public input at the statewide level of the project.

TASK 2: PUBLICIZE THE PROJECT AND THE OPPORTUNITIES FOR PUBLIC INPUT

The beginning is the most critical time in the life of the project to focus on public input. This is true both because most of the important project decisions will be made in the first few months, and because it is more satisfying for people to be involved in a project from the start. Publicizing the project and the opportunities for public input can be done through a variety of mechanisms, including: a press release sent to all newspapers and radio and TV stations in Montana; public service announcements set to radio stations; and an informational mailing sent to organizations and individuals in Montana who could be expected to have an interest in the project. All these materials should describe the scope and purposes of the project, explain why the project is important to Montana's future and hence why public input is important, identify the major topics on which input is sought, and clearly state how to obtain more information.

TASK 3: CONDUCT INTERVIEWS WITH REPRESENTATIVE INDIVIDUALS

An important way to obtain thoughtful input to project decisions is by interviewing individuals known to be interested in the project and representative of a larger segment of the general public. Such individuals can be identified through Task 2 and through other DNRC information sources. It should be possible to interview only 10-20 individuals and still obtain a variety of useful opinions. This task will require some travel and may take a total of 5-15 staff person days.

TASK 4: DESIGN AND CONDUCT A STATEWIDE PUBLIC OPINION SURVEY

This task, which is principally intended to serve Information Dissemination and Impact Analysis needs, can also be used to seek the public's input into some of the choices which must be made in the conduct of the project. The survey should be conducted by mail in a statistically valid manner. Examples of the types of questions which could be asked to obtain public input include: what renewable energy sources are they most interested in having studied? What technologies (if any) are they already considering utilizing? What assumptions would they find believable concerning future fossil fuel supplies and prices? What barriers do they see to the more widespread adoption of specific energy conservation technologies? The results from survey questions like these would serve as useful factors to consider when making the related choices in the conduct of the project.

TASK 5: CREATE A STATEWIDE CITIZEN ADVISORY COMMITTEE

One important and ongoing mechanism for obtaining public input is a statewide citizen advisory committee. The advisory committee should have 10-15 members, and be expected to meet monthly for the first three months of the project, and quarterly thereafter. The committee would serve both as a source of public input to the project and as an informal advisory board of directors. Each advisory committee member should be committed to the project's purposes, be willing to invest the time and energy necessary to make a meaningful contribution to the project, and bring either relevant technical expertise or a valuable perspective. As a body, the advisory committee should represent: a socio-economic cross-section of Montana; different geographic parts of the state; various segments of the energy realm (i.e., producers, consumers, and intermediaries); and a range of points of view about Montana's energy future. The names of possible advisory committee members should be solicited in the course of all these public participation activities, but can also be suggested by DNRC and project staff.

TASK 6: MAKE PERIODIC MAILINGS TO INTERESTED PARTIES

As the project progresses, there will continue to be decisions benefitting from public input. One mechanism for soliciting this input (and one which is also discussed under Information Dissemination Task 4) is to plan to make periodic mailings to individuals and organizations known to be interested in the project. For public input purposes, these mailings would describe upcoming choices or decisions to be made in the course of the project, and ask for comments or suggestions.

TASK 7: IDENTIFY STATE GOVERNMENT LIAISON PERSONNEL

At the state level, much of the information generated by the project will be used by state agency personnel dealing with energy-related matters. For this reason, it is important to involve those people in the design and conduct of the project so that its output will be relevant to their needs. Project staff should identify those bureau chiefs and division administrators who might use project information, and maintain regular contact with them, giving them opportunities to make input to project decisions.

Tasks 8-12 described below relate principally to the need for public input and participation at the model energy community level of the project. In most cases they are comparable to state-level tasks already discussed, so the descriptions will be briefer.

TASK 8: PUBLICIZE THE PROJECT AND THE OPPORTUNITIES FOR PUBLIC INPUT AND PARTICIPATION

As soon as the model energy communities have been selected, an extensive publicity and public education campaign should be conducted. Its purpose will be to inform the residents that the community has been selected, to describe the likely project activities, to explain the decisions needing community input, and to emphasize the opportunities for public participation in project-related activities. Project staff should arrange to be interviewed by local news media, to make presentations to relevant local government bodies and officials, and to speak at meetings of local clubs and civic groups.

TASK 9: CONDUCT INTERVIEWS WITH SELECTED INDIVIDUALS

Much of the success of the project in the model energy communities depends on the extent to which a constituency of individuals and local organizations is developed for the project. Much more so than at the state level, there will be flexibility in the direction the project takes. It will be important for project staff to meet with a range of interested and informed community residents in order to determine the most appropriate focus for the project. This should be a continuing part of the local project staff's responsibilities.

TASK 10: CONDUCT A COMMUNITY OPINION SURVEY

The rationale and objectives of this task are essentially similar to those of Task 4. However, this survey need not be as extensive or statistically rigorous, and hence can probably be conducted in each community by project volunteers over the telephone.

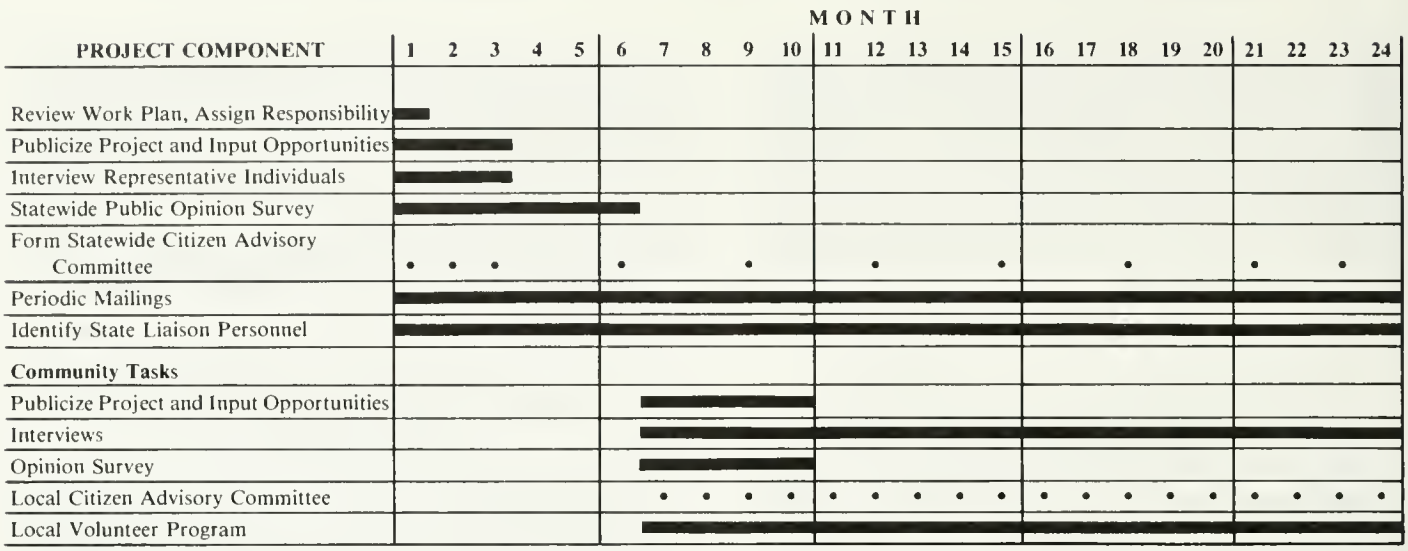
TASK 11: CREATE A LOCAL CITIZEN ADVISORY COMMITTEE

An important mechanism for gaining community support and making the project relevant to each community's needs is a local citizen advisory committee. Its purposes are to provide the project with a local perspective on how it should proceed, to serve as channel for keeping the community informed, and to help promote public participation. The committee might meet monthly, and be composed of 15-25 interested individuals representing a range of community organizations and interest groups.

TASK 12: ESTABLISH A LOCAL VOLUNTEER PROGRAM

The impact of the project on each of the model energy communities will be magnified if a corps of volunteers can be developed to participate in project activities. A task, then, for the local project staff person is to recruit and utilize community volunteers in the project. In many cases this can probably be done working through interested local organizations. But, there may also be a need for the project to develop its own volunteer program, perhaps with an unpaid (i.e., volunteer) coordinator.

Table 25. Public Input and Participation Element Timetable


MONTH
PROJECT COMPONENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Review Work Plan, Assign Responsibility
Publicize Project and Input Opportunities
Interview Representative Individuals
Statewide Public Opinion Survey
Form Statewide Citizen Advisory Committee
Periodic Mailings
Identify State Liaison Personnel
Community Tasks
Publicize Project and Input Opportunities
Interviews
Opinion Survey
Local Citizen Advisory Committee
Local Volunteer Program

• Meetings of advisory committees

Table 26. Budget: Public Input and Participation Element

	Year 1		Year 2		Total
Personnel					
Public Participation Specialists	2 FTE @ $15,000	$30,000	1 FTE @ $16,050	$16,050	$46,050
Benefits (17%)		5,100		2,728	7,828
Personnel Costs		35,100		18,778	53,878
Travel		4,000		3,000	7,000
Computer		—		—	—
Printing		350		150	500
Other					
State Advisory Committee Meetings @ $1,000		6,000		4,000	10,000
Local Advisory Committee Meetings @ $30.00		600		1,200	1,800
Subtotal		46,050		27,128	73,178
Overhead (15%)		6,908		4,069	10,977
Total Cost		**$52,958**		**$31,197**	**$84,155**

INFORMATION DISSEMINATION

OBJECTIVE

The objective of this element of the project is to accomplish a major project purpose—namely, to distribute information which will help in evaluating the opportunities for, and desirability of meeting a portion of Montana's energy needs with renewable energy sources. The types of information to be distributed will be determined by the nature of the information produced in the research phases of the project and by the information needs identified in the tasks described below.

AUDIENCES

It is possible to identify a number of primary audiences for the project. At the state level, energy policy-makers and implementers in both the public and private sectors are the top priority audiences, because of their ability to influence the manner in which the energy needs of Montana are met, and because much of the project's research is policy-focused. At the local level, a number of audiences are equally important: local government officials; residential, commercial and agricultural users of energy; and intermediaries such as bankers and architects. The selection of these target audiences does not preclude project information being useful to other audiences; it merely focuses project efforts on serving the needs of the primary groups.

TASKS

The implementation of this element of the project involves three categories of tasks: identifying information needs; generating information requests; and disseminating information. The tasks are divided into state level activities (5-10), local activities (11-15), and combined activities (2-4). It should be noted that there are also cross-benefits, particularly from state to local activities.

TASK 1: REVIEW WORK PLAN AND ASSIGN IMPLEMENTATION RESPONSIBILITY

When the project is funded and work is about to begin, the work plan should be reviewed, and modified as necessary in light of the current plans for the project. It is important that the overall responsibility for information dissemination be specifically assigned to one individual on the project staff. The combined staffing level for this element of the project and the Public Input and Participation element is such that for state level activities they together require one fulltime person. The duties and skills required are similar enough that such a combination is feasible. For information dissemination purposes, the staff person must be experienced in publicity techniques, able to present technical information in a non-technical way, and able to work well with a variety of people.

TASK 2: CONDUCT INTERVIEWS WITH AUDIENCE REPRESENTATIVES

The most satisfactory way to identify information needs is to ask selected members of each primary audience what information would be most helpful to them in evaluating renewable energy opportunities. At the state level, this means talking to at least one representative of each of the energy information-using agencies (Energy Planning Bureau, Conservation Bureau, Environmental Quality Council, Lieutenant Governor's Office, Public Service Commission, Legislative Natural Resource committees, and private utilities). At the local level, a cross-section of potential users of project information should be interviewed.

TASK 3: INCLUDE QUESTIONS IN THE PUBLIC OPINION SURVEYS

The public opinion surveys, which are being conducted to serve the needs of the Impact Analysis, Transition Analysis, and Public Input and Participation elements of this project, can also be used to help identify information needs. This can be done at both the state and local levels by asking questions about what information people would use to evaluate renewable energy opportunities. Confirming information can be drawn from the Impact Analysis questions which elicit people's reactions to renewable energy alternatives and what they perceive as the positive and negative aspects. These surveys need to be conducted as early in the project as possible.

TASK 4: PUBLICIZE THE PROJECT AND ITS RESEARCH FINDINGS

An important way to generate requests for project information is through on-going publicity about the project's findings. One such technique is a newsletter. Other techniques which should be employed include: press releases announcing the availability of project reports and information; speaking engagements for project staff, and direct contacts with a wide range of organizations interested in energy topics. Publicity activities are particularly necessary at the level where the range of audiences is wider and the types of actions desired are more specific. The project and its research information should be of interest to many people in Montana and probably will be newsworthy in their own right. Project publicity efforts should be able to take advantage of existing channels of communication and other organizations' newsletters.

TASK 5: MAKE PERIODIC MAILINGS TO INTERESTED PARTIES

Periodic mailings to interested individuals can serve a number of project purposes, including promoting public input and assisting in information dissemination. These periodic mailings could take the form of a newsletter published 6-10 times per year or could be incorporated into a DNRC newsletter. A mailing list can easily be developed through contacts established in other project activities and may contain 500-1000 names. As the project progresses, the mailings can serve first to solicit information needs, then to announce the availability of project information, and to summarize key aspects of that information. These mailings are useful principally statewide; there are other more direct ways of reaching people at the local level. A newsletter cannot completely satisfy anyone's information needs, but as a publicity and announcement mechanism it will be valuable to the project.

TASK 6: PUBLISH AND DISTRIBUTE TECHNICAL MATERIALS

The research elements of the project will generate a number of written analysis and reports, maps, computer projections and programs and data tables. All of these materials will be of interest to other agencies and individuals working in the same field. The project should plan to make available all research information in the form of a Technical Report series. These reports, and other materials, will be produced by project staff in the normal course of their research work, but should be prepared with the need for reproduction and distribution in mind. A charge for these materials to cover direct costs would be appropriate.

TASK 7: MAKE COMPUTER MODELS AVAILABLE TO OTHERS

One of the most significant, and unique products of this project will be the statewide supply/demand computer model and its submodels. The information generated by these models for the project will be incorporated into the Technical Report Series. But the models themselves, or access to them, should be made available to any interested parties. The more sophisticated users may want a copy of some or all of the computer programs, probably in computer-readable form; that should be done for a charge equal to duplicating and mailing costs. Most other users (and these may not be too many) will merely need access to the program, i.e., the chance to have project staff run a particular model or submodel with the users' assumptions. This will be an important informational service which the project can provide, again charging for direct costs excluding staff time.

TASK 8: PRODUCE AND DISTRIBUTE STATE POLICY-FOCUSED REPORTS

To meet the needs of state energy policy makers and implementers, a series of specific policy-focused reports

should be produced. These reports should identify specific actions that the recipients could take to encourage a shift to renewable energy sources and an increased reliance on energy conservation, including describing the costs and benefits of the actions. The topics of the reports will be determined largely by the research findings of the other elements of the project. The reports should be tailored to the interests and knowledge level of the recipients.

TASK 9: CONSULT WITH STATE POLICY MAKERS AND IMPLEMENTERS

Many of the above tasks will generate requests for further information and explanation. At the state level, individual contacts, discussions, and meetings will be an important way to increase the use which is made of project information. These consulting activities will involve all project staff at one time or another. The information dissemination staff person should be responsible for seeing that these follow-up contacts are systematically made and the information requests satisfied.

TASK 10: ESTABLISH AN INFORMATION REFERRAL SERVICE

The statewide publicity concerning the project and its research findings will inevitably generate letters, telephone calls, and other information requests which the project will not be designed to satisfy. Project staff should be prepared in these cases to function as an information referral service, directing people to more appropriate sources of the information they need.

TASK 11: PRODUCE AND DISTRIBUTE LOCAL POLICY-FOCUSED REPORTS

Although the local level activities of the project will largely be focused on the model energy communities, there should be a number of barriers and incentives identified in the Transition Analysis which are applicable to many Montana communities. The project staff should plan to produce and distribute reports which focus on the steps local government officials can take to encourage energy conservation and reliance on renewable energy sources. These reports can be announced through project publicity channels, through local government associations, and other means.

TASK 12: PRODUCE AND DISTRIBUTE NON-TECHNICAL LEAFLETS

A major public education effort concerning renewable energy and conservation options should be possible as the project's statewide and local research findings become available. A series of non-technical leaflets should be produced, which highlight and explain project findings. These leaflets will be intended for use principally in the model energy communities but can also be distributed throughout the state through interested organizations. The purpose of the leaflets is to introduce various audiences to particular renewable energy and conservation topics, and to interest them in learning more. An important consideration in producing these leaflets is that they use language their readers can understand, and stress the aspects of the topics to which the readers will be most receptive.

TASK 13: CONDUCT INFORMATIONAL WORKSHOPS

In the model energy communities, a good way to reach specified groups of people (bankers, architects, local government officials, farmers, etc.) is to conduct workshops which present and explain relevant project findings. These workshops should be designed with the needs of the particular audience in mind and can present that information in a focused way. Each model energy community will probably choose to focus on different audiences, but all will be able to draw on research work at both state and local levels. Participation by other agencies and organizations in sponsoring and conducting the workshops should increase their impact and appeal.

TASK 14: PROVIDE INDIVIDUAL CONSULTING SERVICES

There will be many opportunities, both formal and informal, for project staff and volunteers in the model energy communities to provide ideas, advice, and assistance to individuals wanting more information or implementation support. As many of these opportunities as are feasible should be taken advantage of.

TASK 15: HELP ESTABLISH AN ENERGY LIBRARY AND REFERENCE SERVICE

In each model energy community project the staff should work with the local library, or some other suitable organization, to create an extensive reference library of practical information about renewable energy sources and technologies. This reference service would be most valuable if informed volunteers could be found or trained to staff it, answer questions, and provide advice. Such an information center could also be a clearinghouse for speaking requests.

Table 27. Information Dissemination Element Timetable

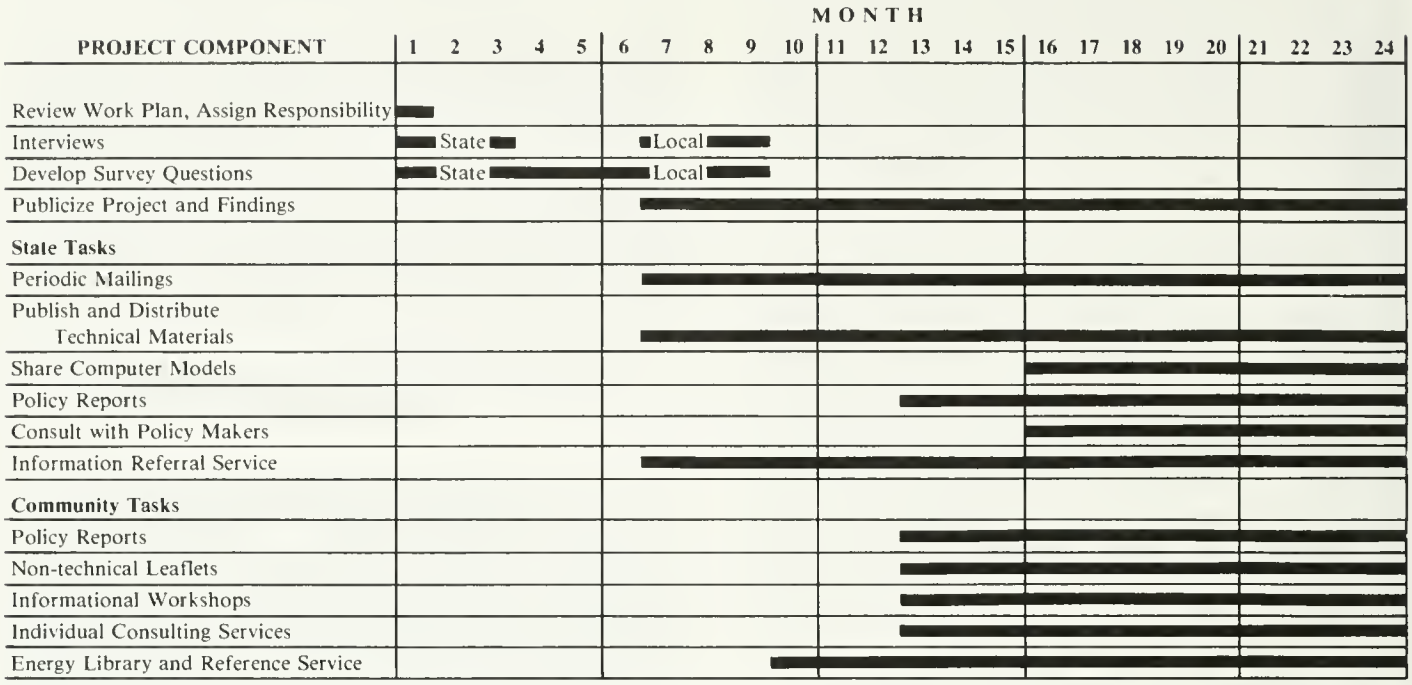


Table 28. Budget: Information and Dissemination Element

	Year 1		Year 2		Total
Personnel					
Information Specialists	1 FTE @ $15,000	$15,000	2.5 FTE @ $16,050	$40,125	$55,125
Benefits (17%)		2,550		6,821	9,371
Personnel Costs		17,550		46,946	64,496
Travel		2,000		4,500	6,500
Computer		—		—	—
Printing		—		4,000	4,000
Other					
Publicity		1,500		4,500	6,000
Subtotal		**21,050**		**59,946**	**80,996**
Overhead (15%)		3,157		8,992	12,149
TOTAL COST		**$24,207**		**$68,938**	**$93,145**

BUDGET

Given the scope of the REV project, the budget may appear quite modest. The budget reflects the following:

1) The REV project is designed to mesh with other program responsibilities of the Montana DNRC.

2) A desire to efficiently use existing information, leaving funding for more direct scientific and engineering R & D work and for implementation.

3) The desire to develop a rigorous analytical framework which can be repeated and refined as new information becomes available. In plowing new ground (as is proposed here), there will be refinements in information and the analytical approach which may suggest different priorities or approaches in subsequent iterations. The objective is to solidly perform one full iteration under the auspices of this project.

Table 29. Renewable Energy Viability Project Budget

	Year 1	Year 2	Total
Management and Administration	$ 43,240	$ 60,313	$103,553
Supply/Demand Element	47,391	50,845	98,236
Technology Profiles Element	58,164	47,314	105,478
Resource Assessment Element	60,047	64,343	124,390
Transition Analysis Element	40,164	84,070	124,234
Impacts Element			
Economic	28,520	30,634	59,154
Social	14,490	15,662	30,152
Environmental	16,894	21,133	38,027
Public Participation/Info Element			
Input and Participation	52,958	31,197	84,155
Information Dissemination	24,207	68,938	93,145
TOTAL COST	**$386,075**	**$474,449**	**$860,524**

Table 30. Renewable Energy Viability Project Personnel Schedule

	Year 1		Year 2		Total
	P FTE*	S FTE*	P FTE*	S FTE*	FTEs
Management and Administration	1.5		1.5	.5	3.5
Supply/Demand Element	1	1	1	1	4
Technology Profiles Element	1	1	1	.5	3.5
Resource Assessment Element	1	1.5	1	1.5	5
Transition Analysis Element					
Local		1.5		3	4.5
State	.25		.5		.75
Impacts Element					
Economic	1		1		2
Social	.5		.5		1
Environmental	.6		.7		1.3
Public Participation/Info Element					
Input and Participation		2		1	3
Information Dissemination		1		2.5	3.5
TOTAL	**6.85**	**8**	**7.2**	**10**	**32.05**

*P FTE is professional full time equivalent personnel
S FTE is support full time equivalent personnel

APPENDIX A

MONTANA RENEWABLE ENERGY VIABILITY PROJECT DESIGN STUDY ADVISORY GROUP

An advisory group representing a broad cross-section of interests in Montana was formed to aid in the development of the project design. The content of the project design does not necessarily reflect the views or opinions of the member's of the advisory group.

A list of those who participated follows:

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APPENDIX B

THE DESIGN STUDY TEAM

The Renewable Energy Viability Project design was developed by a design team led by James H. Nybo, a consulting economist from Helena. Nybo had lead responsibility for coordination of the effort, as well as the development of the management plan, transition analysis, social impacts analysis, qualitative end use analysis, and the final report.

The other members of the design team, by area of responsibility were:

Supply/Demand - Dr. John Duffield, University of Montana, Missoula

Resource Assessment - Montana Engineering Associates, Bozeman:

Dr. Robert Warrington
Dr. Ronald Mussulman

Technology Profiles - National Center for Appropriate Technology, Butte:

Mr. John McBride, Technical Director
Mr. Lane K. Branson, Physicist
Mr. Larry Palmiter, Systems Engineer
Mr. Terry Wheeling, Data Analyst

Economic and Environmental Impact Analysis - Western Analysis, Inc., Helena:

Mr. Richard L. Bourke, Economist and Resource Policy Analyst
Dr. Bruce W. Finnie, Senior Economist

Public Participation and Information Dissemination - Northern Rockies Action Group, Helena - a public interest support organization providing management, advocacy, and media skills to citizen groups primarily in Idaho, Montana, and Wyoming:

Mr. Adam McLane
Mr. Joe Lamson

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC

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